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Fishes of the Western North Atlantic

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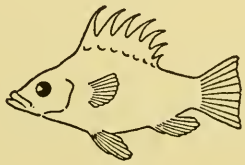

PART TWO

Sawfishes, Guitarfishes, Skates and Rays

HENRY B. BIGELOW *and* WILLIAM C. SCHROEDER
Museum of Comparative Zoology

Chimaeroids

HENRY B. BIGELOW *and* WILLIAM C. SCHROEDER

NEW HAVEN 1953

SEARS FOUNDATION FOR MARINE RESEARCH, YALE UNIVERSITY

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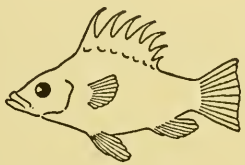
Fishes of the Western North Atlantic



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Introduction

WITH THE PUBLICATION of the second part of Fishes of the Western North Atlantic it seems desirable to restate briefly the purposes and aims of this series, particularly for those who may not be familiar with Part One. In ichthyology, as in other sciences, much of the early work was devoted to purely descriptive accounts which appeared in numerous publications here and abroad, and although new species are still described occasionally, a stage of relative stability has been achieved in our knowledge of the species which occur in the western North Atlantic. At this time, therefore, it seems particularly important to bring together and synthesize the vast amount of information which has been amassed in the past and thus make it available to both public and marine biologists. It is intended that each article in this series shall be a critical review and revision rather than a mere compilation of previously published works, and, as pointed out in the Preface to Part One, that it be "written on the premise that it should be useful to those in many walks of life—to those casually or vitally interested in the general phenomena of life in our waters, to the sportsman whose interests are closely associated with pleasure and relaxation, to the fisherman whose livelihood depends upon knowledge of where fishes are gathered together, as well as to the amateur ichthyologist and the professional scientist."

Part One, published in 1948, dealt with the Lancelets, Cyclostomes and Sharks of the western North Atlantic. The present publication, treating of Sawfishes, Guitarfishes, Skates, Rays and Chimaeroids, brings to completion a further effort in the over-all purpose of this series. In general the format and treatment of these groups are the same as in Part One. In conformance with general policy, these studies also are written for the layman as well as the specialist and are critical reviews rather than perfunctory compilations. The text, together with meticulously accurate illustrations, should leave no place for confusion in the reader's mind. As in Part One, under each species will be found not only a detailed description and the distinctive characters which set it apart from its nearest relatives, but notations on color, size, general habits, abundance, range, relation to man, and occurrence. The geographical range of the fishes described remains essentially the same—the western half of the North Atlantic, including the adjoining gulfs and seas, from Hudson Bay southward to the Amazon River. Numerous species found in other parts of the globe are often referred to, and occasional species from adjoining seas are described.

Again we wish to acknowledge our gratitude to the Sears Foundation for Marine Research, which has financed the publication. We are also grateful to the Woods Hole Oceanographic Institution and the Museum of Comparative Zoology, which have contributed in large measure to these publications through salaries to the authors and through special grants for the preparation of illustrations and for travel to examine specimens. We are likewise indebted to those institutions which have generously supported the work of the editors, particularly the Bingham Oceanographic Laboratory, the American Museum of Natural History and the New York Zoological Society.

The Editorial Board again expresses its particular appreciation and thanks to Yngve H. Olsen, who has edited the manuscripts and seen them through press with untiring patience and enormous skill and to Henry Sears for his continued interest and support.

Finally, we note with profound regret the death of the late Dr. Samuel F. Hildebrand, who served the field of ichthyology so well and long and who gave so generously of his time and experience as a member of our Editorial Board.

John Tee-Van,
New York Zoological Society.

February 1, 1953

North America

South America

CHAPTER ONE

Sawfishes, Guitarfishes, Skates and Rays[1]

BY

HENRY B. BIGELOW *and* WILLIAM C. SCHROEDER

ACKNOWLEDGMENTS

Many persons have assisted us in the preparation of the following pages. Our thanks are due in particular to Leonard P. Schultz and to A. S. Romer for allowing us free access to the collections of the United States National Museum and of the Harvard Museum of Comparative Zoology, which have been the chief sources of our Study Material; to the authorities of the British Museum (Natural History), the American Museum of Natural History, the Academy of Natural Sciences of Philadelphia, the Boston Society of Natural History, the Chicago Museum of Natural History, the Charleston Museum, South Carolina, and the Museum of Zoology, University of Michigan, for the loan of much needed material; to the Woods Hole Oceanographic Institution for constant assistance; to Stewart Springer who has contributed a large amount of valuable information and many specimens of Skates, Rays and Chimaeras from Florida and the Gulf of Mexico; to Anton Fr. Bruun for the loan of rhinochimaeroid material collected by the ATLANTIDE *Expedition from deep water off equatorial West Africa; to J. L. Baughman for Sawfishes, Guitarfishes, and other specimens from the Gulf of Mexico; to Gordon Gunter for Guitarfishes from Texas; to Michael Lerner and C. M. Breder for obtaining two specimens of* Manta *for us at Bimini, Bahamas, and to Ivor Cornman for arranging to have parts of them shipped to Cambridge; to William Royce and the scientific staff of the*

1. Contribution No. 570 from the Woods Hole Oceanographic Institution.

U. S. Fish and Wildlife Service vessel ALBATROSS III *for desirable specimens and data on Skates and Rays from the North Carolina Coast taken during midwinter; to Luis Howell-Rivero for Cuban Rays; to Captain R. Howard, A. U. S., for Torpedo and Sting Rays from the east coast of Florida; to Marie Poland Fish for Rays from Rhode Island; to Leslie W. Scattergood for information as to the season for* Raja ocellata *with egg cases off the coast of Maine; to Paul M. Hansen for specimens of* Raja radiata *from Greenland and for other information; to Captain C. W. Thomas, U. S. C. G., and Commander P. L. Stimpson, U. S. C. G., for obtaining specimens of* Raja hyperborea *for us in West Greenland; to Commander David C. Nutt and Richard H. Backus for records of* Raja radiata *from Labrador; to W. Templeman for a specimen of* Raja spinicauda *from northeastern Newfoundland, for specimens of* R. radiata *from the Grand Banks, and for other information; to V. D. Vladykov for specimens of* Raja erinacea *from the estuary of the St. Lawrence River; to Miss Ethelwyn Trewavas of the British Museum (Natural History) for supplying the description of the type specimen of the Devil Ray* Ceratobatis robertsii *and for arranging to have drawings of it prepared by Hubert Williams; to G. Palmer for drawings and measurements of* Diplobatis pictus*; to Dr. George White, J. Incardone, and W. E. Kruger for the x-ray photographs reproduced in Fig. 62, and to Dr. Leonard D. Nathan for his assistance in obtaining x-rays; to Señora Helena Paes de Oliveira for photographs of Brazilian Skates; to John Tee-Van for contributing bibliographic citations without which the work could hardly have been undertaken; to Ludlow Griscom and James L. Peters for assistance in nomenclatural problems; to H. W. Fowler for welcome information on various Skates and Rays; to Frank Huber for notes on a large* Manta *taken off New Jersey; to F. E. Firth, and Captains Donald Campbell and Frank Janssen for interesting records of offshore captures of* Torpedo nobiliana*; to Captains Henry W. Klimm, Jr. and Jared Vincent for furnishing information on the captures of various Skates on the offshore winter fishing grounds off southern New England; to J. C. Brew, Sir P. H. Buck and Captain E. H. Bryan for assembling information on the use of Sting Ray spines as weapons in various parts of the world, and to Mrs. Myvanwy Dick for much assistance in the preparation of the manuscript.*

GENERAL DISCUSSION

Scope of Study. The following pages give descriptions, illustrations, life histories, geographic distribution, and references for all species of Sawfishes, Guitarfishes, Skates and Rays that are known in the western side of the North Atlantic. The characterizations of suborders, families, and genera, together with the corresponding Keys, cover the batoid fishes as a whole; this also applies to Species Keys in cases where present knowledge permits.

Descriptions. The descriptions are based on the Study Material listed under each species, except for *Urotrygon microphthalmum* and *Mobula mobular*, no specimens of which were available. The accounts of habits and distribution are based on published data, on information from correspondents whose assistance is acknowledged, and on our own observations.

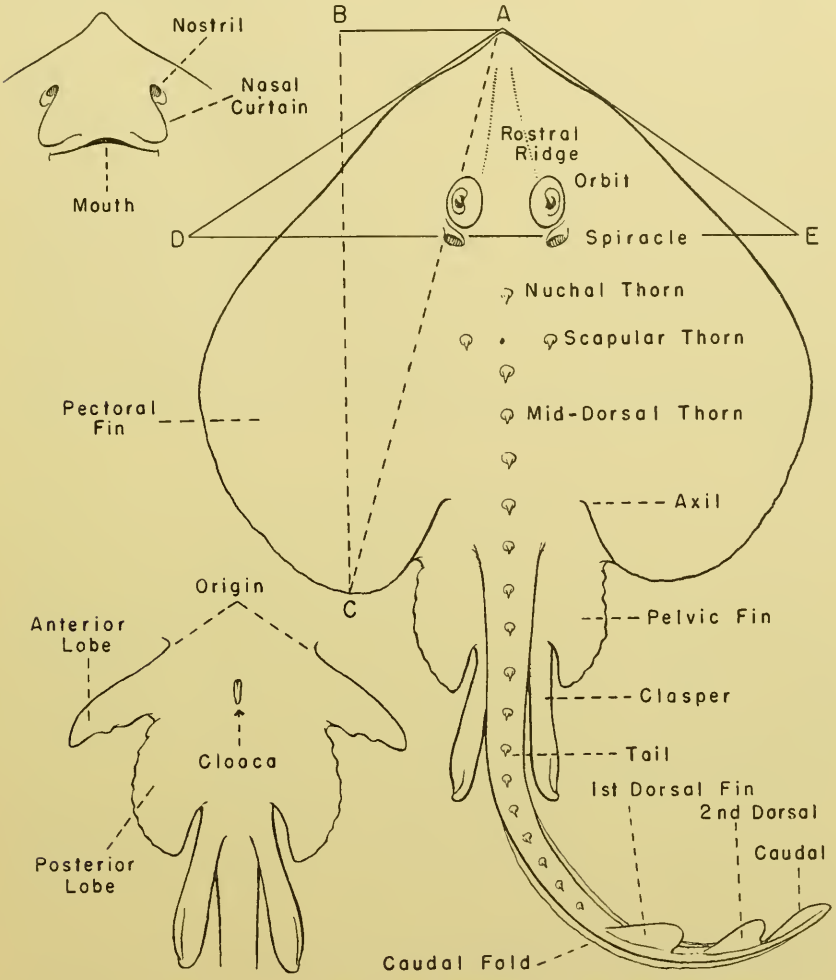

FIGURE 1. Outlines of a typical Skate to illustrate terminology and methods of measurement.

1*

Keys. The Keys are offered solely for purposes of identification. Therefore, we have selected for their construction such characters as are not only alternative but which are easily seen or measured.

Arrangement. The larger groups, down to genera, are arranged in the sequence that seems to us to represent most nearly their probable relationships. The species within each genus are presented in alphabetical sequence as in our previous publication, *Sharks.*[2]

References. All citations were consulted in the original, except as noted, through the co-operation of the several libraries listed previously.[3]

Sources of Material. The collections in the Harvard Museum of Comparative Zoology and the United States National Museum have been the chief sources of our Study Material. We are much indebted also to the museums and persons listed (page 1).

Proportional Dimensions and Illustrations. The measurements from which the proportional dimensions of the several species have been calculated were taken on a horizontal line between perpendiculars at given points; for example, the length of the snout in front of the orbits is on line BC in Fig. I, *not* AC; the length of the disc is measured on line BC, *not* AC; the anterior angle to the level of the spiracles is the angle DAE.

The great majority of the drawings in this book were prepared by the well known zoological artist, E. N. Fischer, who executed most of the illustrations for Part I of this Memoir series and for Garman's Plagiostoma (1913). *Ceratobatis robertsii*, the type specimen of which is in the British Museum (Natural History), was drawn by Hubert Williams, and original drawings of *Diplabatis pictus* were loaned to us by courtesy of G. Palmer.

Subclass ELASMOBRANCHII

Order BATOIDEI

Sawfishes, Guitarfishes, Skates and Rays[4]

Characters. In the Batoidei the gill openings are wholly on the ventral surface. The anterior edges of the pectorals are united with the sides of the head forward past all five pairs of gill openings, about to the level of the mouth in some (Pristidae), to the level of the nostrils in others, to the tip of the snout in still others. The upper edges of the orbits are not free from the eyeballs, as they are in Sharks; that is, they do not have free upper eyelids. In these respects they differ from all modern Sharks. None have nictitating membranes, anal fin, or precaudal pits or furrows.

The great majority of the batoids are easily recognizable by their shapes. Their trunks are strongly flattened dorsoventrally, with the pectorals widely expanded so that they are disc-like in shape. The tail sector is more or less distinct from the body sector, the eyes and spiracles are on the dorsal surface, and the mouth, as well as the entire lengths of the gill openings, is on the ventral surface.

2. Bigelow and Schroeder, Mem. Sears Found. Mar. Res., I (1) Chap. 3, 1948.
3. Mem. Sears Found. Mar. Res., I (1), 1948: 60.
4. For characters of the order Selachii, see Mem. Sears Found. Mar. Res., I (1), 1948: 62–64.

However, one group, the Sawfishes (Pristoidea), are shark-like in general appearance, though they are grouped among the batoids because of the relationship of the pectorals to the gills and because of the absence of upper eyelids, as well as on skeletal grounds. And most of the Guitarfishes (families Rhynchobatidae and Rhinobatidae) are intermediate in form, between shark-like and batoid-like.

Some batoids have no dorsal fin, whereas others have one or two, in which case the first dorsal (when there are two) varies in position from over the pelvics to far back on the tail. Some have a distinct caudal fin, which others lack. In all fins of some species the radial cartilages are supplemented distally (as in Sharks) by much more numerous fine horny rays (ceratotrichia) in double series, their inner ends embracing the outer ends of the cartilaginous radials; in others the unpaired fins have these horny rays whereas the pectoral and pelvic fins, in which the cartilaginous radials run out nearly or quite to the margin, do not; in still others neither the unpaired nor paired fins have horny rays. The spiracles are larger than those of most Sharks and are situated on top of the head in all cases; the rudimentary spiracular gill filaments are better developed than in Sharks, as is also the so-called spiracular valve, a stiff concentric fold of connective tissue on the anterior margin of the spiracle which is supported by a strong cartilage fixed at each end. The eyes are well developed in most, though degenerate in a few. All have five pairs of gill openings.

The skins of some are naked while those of others are variously armed with thorns, tubercles or prickles; the tails of some bear large saw-edged spines. The teeth vary from thorn-like to rounded or platelike (none have the blade-like dentition so characteristic of many Sharks), placed either in bands, in transverse rows, or in pavement or mosaic arrangement. The nostrils are connected with the mouth in some cases but are entirely separate from it in others. In one family, the Sawfishes, the snout is produced as a long flat blade supported by the rostral cartilages in the form of five or more calcified tubes (described on p. 16) and is armed along either edge with a single series of strong tooth-like structures, much as in the Saw Sharks (Pristiophoroidea). The heart valves are in two to seven rows.[5]

Some members of the order have electric organs more or less well developed, but none have luminescent organs so far as is known.

The vertebral column is completely segmented throughout its length in all species, with the centra fully differentiated and the axial canal so greatly constricted in its passage through them that the notochord is wholly or almost wholly obliterated there. Secondary calcifications of the vertebral centra in the form of radiating lamellae are described as growing inward toward the primary calcified double cone.

The Batoidei in which the anatomy has been studied, including the Sawfishes, differ from all modern Sharks in the attachment of the pectorals to the sides of the head, in the lack of a free upper eyelid, in the better developed spiracles, in the ventral

5. See Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 56, figs. 7–10, pl. 57, figs. 1–6) for illustrations from original dissections of the heart valves of various batoids; see White (Bull. Amer. Mus. nat. Hist., *74*, 1937: 87, 91) for a general discussion of their significance in classification and for tabulations of their numbers in various Sharks and batoids.

positions of the gill openings, and in a number of skeletal characters, of which the following may be selected as the most obvious:

The upper jaw cartilage is attached only loosely to the cranium, at most, by a ligament of considerable length.

The cranium is firmly connected with the vertebral column by a definite articulation between its posterior face and the anterior vertebra by means of two condyles which are lacking in Sharks.

The first few vertebrae, differing in number in different families, are united together as a continuous rigid tube.[6]

The ceratohyal cartilage is attached only to the lower end of the hyomandibular and thus plays no direct part in the support of the lower jaw, which is suspended from the hyomandibular alone.

The shoulder girdle is directly and firmly attached to the vertebral column, either above the latter by a special scapular element (or elements) or to its sides.

The propterygial cartilage of the pectoral bears at least as many radials as the metapterygial cartilage and many more than the mesopterygial, which is much smaller than either the propterygial or the metapterygial.

The union of the two halves of the upper jaw at the symphysis is much more intimate in many batoids than in Sharks, but not in all.[7] On the other hand, the connections between the anterior parts of the upper jaw cartilages and the cranium, being by ligament only, are less intimate among the batoids than they are in many Sharks, though the two groups intergrade in this respect.[8]

It has long been known that the attachment of the pectorals to the sides of the head in batoids is a secondary development, for the early embryos of even the most highly specialized of them are slender-bodied like those of Sharks, with the rudiments of the pectoral fins at first wholly posterior to the gill openings. As development proceeds, the pectorals expand rearward as well as forward past the gill openings in a form that has been variously described as blade-like or horn-like. The anterior horns of the pectorals then fuse with the sides of the head above the five posterior gill openings that are destined to persist as such but below the persistent portion of the first embryonic gill openings that are destined to form the spiracle of the adult. The sequence of events of this transformation of the pectorals has been observed among Skates (Rajidae), among Torpedoes (Torpedinidae),[9] and among Sting Rays.

6. For excellent illustrations of the anterior part of the vertebral column showing this fusion, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 55, figs. 3–10).
7. This is true of the Rajidae but not of the genus *Gymnura* (Dasyatidae), in which the two halves of each jaw cartilage are clearly separated.
8. For further information on this point, see Bigelow and Schroeder (Mem. Sears Found. Mar. Res., I (1), 1948: 65).
9. The sequence of stages leading to the fusion of the anterior parts of the pectorals with the sides of the head seems to have been observed first by Leuckart (Z. wiss. Zool., *2*, 1850: 261, pl. 16, figs. 1, 2) in the Mediterranean *Torpedo marmorata* more than a century ago. For other illustrations of embryo torpedinids with the anterior parts of the pectorals still wholly or partially free, see de Sanctis (Atti Accad. Sci. fis. mat. Napoli, *5*, 1873: pl. 1, fig. 9), Goodrich (in Lankester, Treat. Zool., *9*, 1909: 754, fig. 117), Prashad (Rec. Indian Mus., *19*, 1920: pl. 7, figs. 7, 8), and especially Waite (Rec. Canterbury [N. Z.] Mus., *1* [2], 1909: pl. 18, fig. 3); see also p. 101, Fig. 23. The process was described and pictured in some detail by Wyman (Mem. Amer. Acad. Arts Sci., [N. S.] *9*, 1867: 35, 1 pl.) in his classic

Batoids in which the forward wing-like expansions of the pectorals have failed to unite with the head are caught occasionally, and monstrosities of this sort have served as the bases for new generic names (pp. 138, 139, 397).[10]

The absence of the anal fin among all batoids is equally a secondary character, for their embryos develop this fin, as do those of Sharks, but they lose it at an early stage in their development.[11]

Spiracular Breathing. It is common knowledge that the spiracles play a much more important role in respiration among most of the batoids than in any modern Shark. In many of the latter, water is taken in solely through the mouth in breathing and chiefly through the mouth even by such of them as inhale somewhat through the spiracles, for example *Squatina*. Most of the batoids, however, take in water chiefly through the spiracles. Although it has been observed that Skates (genus *Raja*) which usually hold the lower surface of the head slightly elevated above the bottom do inhale some water through the mouth, it is likely that Sting Rays, when well buried in the sand, as they often are, take in water through the spiracles alone.[12] But the Devil Rays (Mobulidae) respire chiefly or wholly through the mouth, and their spiracles are correspondingly small (p. 484).

The spiracles of a Skate or Ray, breathing undisturbed, open and close at roughly regular intervals, as one can easily see by watching one in an aquarium, closure being effected mainly by the contraction of their anterior margins that bear the rudimentary gill filaments and the spiracular valve. The water that is taken in through the spiracles when the pharyngeal cavity is expanded is prevented from passing out through the mouth by the presence of a broad transverse fold of the oral membrane on the roof of the mouth and by a narrower one on its floor ; the water is thus directed to the gill openings when the pharyngeal cavity is contracted. When a Sting Ray is buried in the sand, the periodic expulsion of water through the gills is made evident by "a regular geyser of sand grains arising to an inch or two in height at the anterior margin of the pectoral fin."[13] In one set of experiments,[14] the rate of respiration in a Skate (*Raja*), easily measured by timing the contractions and expansions of the spiracles, varied from about 30 per minute at rest to 47.5 per minute after exercise.

It is also well known and easily observed that the direction of flow through the spiracles is occasionally reversed in Skates (*Raja*), in Sting Rays (*Urolophus*), in Guitarfishes (*Rhinobatos*), and also in Angel Sharks (*Squatina*). In a Skate at rest this was seen to happen at intervals of five to ten minutes. And it has been shown experimentally that this spouting can be brought about in various ways, i.e., by fatigue, by partial

paper on the development of *Raja*. For accounts among Sting Rays, see Hill (Proc. Linn. Soc. N. S. W. [2] 10, 1895: 208) and Daniel (Elasmobranch Fishes, 1934: 11, fig. 22, B. C.) for *Urolophus*.

10. For a good general account with illustrations, see Gudger (Amer. Mus. Novit., 600, 1933).

11. For illustrations showing the anal fin in the embryo Skate, see Wyman (Mem. Amer. Acad. Arts Sci., [N. S.] 9, 1867: pl. to face p. 44, figs. 6–9).

12. See Rand (Amer. Nat., *41*, 1907: 287–302), for observations and experiments on the spiracular breathing of Skates (*Raja*), and Daniel (Elasmobranch Fishes, 1934: 156–157), for similar observations on Sting Rays (*Urolophus*), Guitarfishes (*Rhinobatos*), and Angel Sharks (*Squatina*).

13. Daniel, Elasmobranch Fishes, 1934: 157.

14. Rand, Amer. Nat., *41*, 1907: 293.

asphyxiation from an excess of carbon dioxide in the water, or by mechanical stimulation. But seemingly the normal function of this reverse flow is to wash the eyes clean of sand grains that may fall upon them and to clear the spiracles of fragments of seaweed and other objects that may be drawn into them with the intake of water.

Size. The members of the order range in size from a breadth of only a few inches (the smallest Rajidae and Torpedo Rays) to the enormous Devil Rays that sometimes grow to a breadth of 22–23 feet and to a weight of more than 3,000 pounds. The Sawfishes (Pristidae) reach a length of at least 20 feet and exceptionally even more.

Locomotion.[15] The Sawfishes (family Pristidae) propel themselves chiefly with the posterior part of the trunk by lateral undulations which are effected by waves of muscular contraction that progress from front to rear and thus push against the water; this action is combined with lateral strokes of the caudal fin, perhaps aided also by a sculling action of the latter and by undulating movements of the pectorals.[16] Locomotion is chiefly caudal also in the Guitarfishes (Rhinobatidae), though the pectorals may be of some aid in their swimming.[17] The Torpedoes swim chiefly with the posterior part of the trunk, aided by the caudal fin, their discs not being flexible enough to be of much service in locomotion. The Skates (Rajidae) are driven ahead by the simultaneous passage of waves of undulation through the two pectorals from front to rear. Each undulation originates as an elevation of the anterior margin of the pectoral, which is lowered as the undulation passes rearward through the fin. The undulation increases in amplitude until it reaches the midlevel of the disc, posterior to which it decreases in amplitude as it continues to progress rearward. Then a new wave arises at the front of the fin just before the preceding wave has entirely died away at the posterior edge. In one species of Skate the time occupied by an individual undulation in its progress from the front of the pectoral to the rear was 0.6–0.8 seconds. The Sting Rays (Dasyatidae and Urolophidae), as exemplified by *Urolophus*, use their pectorals in the same way.[18] All the batoids that do this advance by a smooth gliding motion, often right along the bottom. But the Eagle, Cow-nosed, and Devil Rays (Myliobatidae, Rhinopteridae, Mobulidae) have been described repeatedly by competent eye-witnesses as progressing by flapping their pectorals, more in the manner of birds. And some of them have the habit of leaping into the air or of planing at the surface, a spectacular sight when a school breaks the surface simultaneously, as sometimes happens (p. 485).

The Sawfishes, Guitarfishes, and Torpedoes doubtless steer from side to side, as do Sharks and most other fishes, by a progressive curvature caused by a wave of muscular contraction from the anterior part of the body toward the tail, which is then swung

15. For a general discussion of locomotion in fishes (including elasmobranchs), see Breder (Zoologica N. Y., *4*, 1926: 159–297); for a recent analysis of the mechanics of propulsion by undulations of the trunk in various fishes, including Sharks, illustrated by moving picture photographs, see J. Gray (J. exp. Biol. Lond., *10*, 1933: 88–104).
16. Breder (Zoologica N. Y., *4*, 1926: 243) describes the pectorals of the Sawfishes (*Pristis*) as "fluttering" during swimming and suggests that they may have some propulsive effect.
17. In *Rhinobatos* the pectorals "may be put to considerable use other than in steering, as may be seen upon grasping the tail and attempting to pull the fish out of the water" (Daniel, Elasmobranch Fishes, 1934: 13).
18. See Mârey (C. R. Acad. Sci. Paris, *116*, 1893: 77, 2 figs.) for analysis by moving pictures of this pectoral locomotion in *Raja*, and Daniel (Elasmobranch Fishes, 1934: 13) for *Urolophus*.

toward the inner side of the curve.[19] Skates also appear to employ the tail to some extent in turning. But the chief method by which they turn, and the only method for the members of the order in which the tail is either very slender or very short, is by interrupting the undulations of the pectoral on the one side while those on the other side are continued, or by varying the rates at which the waves of undulation pass along the two pectorals; the Ray swings to the right if the undulation is the more rapid on the left-hand side thus driving the left-hand side ahead the more rapidly, or it swings to the left if it is the right-hand undulation that is the more rapid.

Breeding and Development. Fertilization is internal in all the batoids and is effected in the same manner as among Sharks, i.e., by a pair of appendages, known as claspers, that develop in the male from the inner edges of the pelvic fins. Their presence makes the determination of the sex easy, for they are visible even in embryos shortly before birth. The inner margins of the claspers are deeply grooved, with the edges more or less overlapping for the transmission of sperm that is received at their inner ends via an opening known as the apopyle. The primary support of the clasper consists of a single basal cartilage connected with the basypterigial cartilage of the pelvic fin by 2–4 short intermediate pieces. During growth this basal element elongates while other cartilages are formed secondarily from the surrounding connective tissue. Two of these secondary cartilages, more or less elongate, lie alongside the primary basal element, with which they fuse either wholly or partially to form a rigid axial rod. As maturity approaches a series of additional terminal cartilages develop in varying numbers (2–5 or 6 in different groups), often in an exceedingly complex arrangement that exhibits a wide range of forms, blade-like and knife-sharp in some cases though covered by a thin layer of integument, or emerging from the skin as thorns in other cases. Some of these terminal elements may be more or less erected at right angles to the general axis of the clasper during copulation.[20]

The members of one family (Rajidae) are oviparous; their eggs, enclosed in horny capsules (p. 141), are familiar objects on the seashore. All other members of the order, so far as is known (with one possible exception, p. 47, fn. 11), are ovoviviparous, the embryos developing within the oviducts of the mother until they are ready for independent existence. But there is no placental connection between young and parent.

The embryos of the myliobatoid Rays as a group, and of some of the Electric Rays, are nourished by a secretion from the vascular villi that clothe the inner wall of that portion of the oviduct—the so-called uterus—where the embryo lies (pp. 91, 383, 397). But it is not known whether this is true of those rhinobatoids in which the uterine wall bears only a series of longitudinal folds and no villi (p. 52) or of some Torpedo Rays in which the structure of the uterus is similar. There is no reason to suppose that

19. For recent discussion, with moving picture photographs showing successive positions assumed by a flexible-bodied Shark (*Scyliorhinus caniculus*) in turning sharply, see J. Gray (Proc. roy. Soc. Lond., [B] *113*, 1933: 118, pl. 4).

20. For discussion and illustrations of the skeletal elements of the claspers in representative batoids, see especially Jungersen (Danish "Ingolf" Exped., *2* [2], 1898: pls. 3, 4; Anat. Anz., *14*, 1898: 498–513). For detailed accounts of the soft parts of the claspers, see Haber (Z. wiss Zool., *70*, 1901: 627–634, pl. 28); for a more recent account (with complex terminology for the various parts), see Leigh-Sharpe (J. Morph., *34*, 1920: 260; *36*, 1921: 213–218, 236–243; *39*, 1924: 560, 568–577; *42*, 1926: 318–320).

the embryos of any of the batoids feed on unfertilized eggs that lie close to them in the maternal oviduct, as do the embryos of Mackerel Sharks (*Lamna*) and of the Sand Shark (*Carcharias taurus*) of the western North Atlantic.[21]

Luminescence. None of the batoid fishes have luminescent organs so far as is known.

Habits and Food. Most of the batoids are comparatively sluggish, living on the bottom or close to it. Even the Sawfishes (Pristidae) keep close to the bottom, except when they may rise among a school of fishes; although they are slow swimmers they are strong, as any angler will testify who has hooked or harpooned one. The Guitarfishes (Rhinobatidae and Rhynchobatidae) either swim about slowly close to the bottom or lie half buried. The Torpedoes (Torpedinoidea) lie buried in the mud or sand most of the time and swim but feebly. The Skates (Rajidae) either lie flat on the bottom, often with their pectorals partly buried, or swim along slowly close to it. But they can dart ahead with astonishing velocity if disturbed or if in pursuit of prey (p. 143). The Sting Rays and their kin (Dasyatidae, Urolophidae) have much this same way of life, except that they are rather more likely to be wholly buried except for eyes and spiracles. The Butterfly Rays (Gymnuridae) also hold close to the bottom, though perhaps moving to and fro more actively with changes of the tide than most of the dasyatids (p. 413). However, the Eagle (Myliobatidae) and Cow-nosed Rays (Rhinopteridae) are decidedly more active, for while they feed right on the bottom (pp. 437, 466) they often swim actively at midlevels or near the surface, sometimes leaping clear of the water, as described elsewhere. The Devil Rays appear to have abandoned the bottom-living habit largely and spend most of their time swimming close to the surface (p. 485).

The batoids, like the Sharks, subsist wholly on animal food, and the lists of stomach contents so far recorded are varied enough to show that practically all of the invertebrate groups characteristic of sandy or muddy bottoms contribute to the diet of one or another Skate or Ray. The Eagle and Cow-nosed Rays as a group subsist chiefly on hard-shelled mollusks, but they are known to take crustacea on occasion (p. 473). The dasyatid and Butterfly Rays (Dasyatidae, Gymnuridae) are rather more catholic in their tastes, consuming small fish as well as crustacea and mollusks. Skates (Rajidae) as a group probably depend chiefly on whatever crustacea may be available locally, but they also devour mollusks, polychaete worms, and cephalopods of the less active sorts, as well as small fishes, on which they may feed exclusively at times (p. 223).

The Sawfishes (Pristidae) feed chiefly on fishes (p. 19) but to some extent on bottom-living invertebrates as well. Some of the Electric Rays (Torpedinoidea) are strictly fish-eaters, sometimes devouring fishes of considerable size relative to themselves, whereas others subsist on small bottom-living invertebrates.

Most interesting of all are the feeding habits of the Devil Rays (Mobulidae). In spite of the great size to which some of them grow, they feed on small crustacea, small fishes, and other members of the animal plankton which are directed by the fin-like cephalic appendages into the mouth, there to be sifted out (from the water that is taken in at the same time) by the so-called prebranchial apparatus, as is described on p. 483.

21. Springer, Copeia, 1948: 154.

The largest of the batoids thus feed in essentially the same manner as do the Basking Shark and the Whale Shark.

Relation to Man. The Skates (Rajidae) are of considerable value to the fishermen of Europe, as described on p. 145. But they are in little demand elsewhere. None of the other batoids are of any great commercial importance, for while Rays in considerable variety are brought in to fish markets in tropical ports in various parts of the world, the number involved is small. A minor use has been made of the spines of Sting Rays to tip spears or to arm the lashes of whips, as described later (p. 338). The large Devil Rays are pursued to some extent with the harpoon as objects of sport. Otherwise, the chief importance of Rays to fishermen is their nuisance value, some of them because they take the baits intended for better fishes (p. 145) and others because of the injuries they are capable of inflicting by their serrate spines on anyone who may handle them incautiously or who may tread on them while wading on flats in regions where they are plentiful (p. 336).

Habitat and Range. The latitudinal range of the batoids as a group extends from the Equator to the subpolar belt in both hemispheres, and their distribution is equally wide in all three great oceans, Atlantic, Pacific, and Indian, including the tributary seas. Nor can the group as a whole be described as chiefly characteristic of any particular latitudinal zone. While the most numerous group of all (Rajidae) has reached its maximum development (whether as to species or as to number of individuals) in the temperate-boreal belts of the two hemispheres, the Sting and Butterfly Rays and their kin (Dasyatidae, Gymnuridae, Urolophidae), the Eagle and Cow-nosed Rays (Myliobatidae, Rhinopteridae), the Devil Rays (Mobulidae), the Sawfishes (Pristidae), and the Guitarfishes (Rhinobatidae, Rhynchobatidae) are more numerous in tropical and subtropical waters, with the Electric Rays as a group occupying an intermediate position.

A similar ecological cleavage appears with regard to the range in depth between the Skates (Rajidae) and certain Electric Rays on the one hand and all other batoids on the other. The latter, so far as is known, are most abundant by far in shoal water. But the Electric Rays range from close to the tideline down to at least 500 fathoms, while the Skates not only extend down to 1,500 fathoms but are extremely abundant at depths (20–100 fath.) at which the great bottom fisheries of northern Europe and eastern North America are chiefly carried on (p. 144). It has been discovered[22] recently that the bottom along the north coast of Cuba, at depths of 200–500 fathoms, supports an abundant community of Skates, several species of which have not been found elsewhere. Even more recently we have found that there exist in the Gulf of Mexico, in depths of 50–300 fathoms, some additional species which are new to science (pp. 286, 314).

Consequent on their wide distribution both in latitude and depth, the batoids cover nearly as broad a thermal range as do the bony fishes, i. e., from the highest temperatures to which the water warms over the shallows in tropical estuaries to polar waters that may be as cold as −1.5° C (about 29° F). However, only one species (*Raja*

22. Bigelow and Schroeder, J. Mar. Res., 7, 1948: 543.

hyperborea, p. 206) is known to find a congenial home regularly in water colder than 0° C (32° F), and perhaps a second species (*R. spinicauda*, p. 271).

As a whole the batoids constitute a salt-water group, but several species of Sting Rays (family Potamotrygonidae, p. 334) have colonized fresh water in the lower reaches of South American rivers that drain into the Atlantic (p. 334). Sawfishes are also found regularly in fresh water and are even landlocked.

Geological History. The Guitarfishes (Rhinobatidae), which are intermediate in form between the more highly specialized groups of Rays and the Sharks, were in existence in the Upper Jurassic. Thus the oldest batoids were more recent in their geological appearance than the oldest of the groups of Sharks that exist today,[23] and they were far more recent than some extinct groups of Sharks. The Sawfishes (Pristidae), the Skates (Rajidae), and the Sting and Eagle Rays (Dasyatidae, Myliobatidae) appeared in the Cretaceous, the Torpedo Rays in the Eocene, and teeth identifiable as those of a Devil Ray, closely allied to the modern *Manta*, are known from the Pliocene.[24]

Classification. Scientific opinion is now tolerably crystallized as to the basic grouping of the batoids, though the taxonomic systems that have been proposed by different students during the last half century have differed widely as to the number of subdivisions recognized and as to the names employed for the groups above the grade of family.[25]

Beginning with the Electric Rays: these are sharply set apart from all other batoids by the possession of highly developed electric organs in the anterior part of the body, by the greatly expanded antorbital cartilages that support the anterior margin of the disc, by the peculiar branched rostral cartilage or cartilages, and by the rounded plate-like terminations of the slender branchial cartilages. We follow common usage

23. The Port Jackson Sharks (Heterodontidae) date back to the Lower Jurassic, the Six-gilled Sharks (Hexanchidae) to the Middle Jurassic.

24. See Romer (Vert. Palaeont., 2nd ed., 1945: 577) for a list of the geological horizons from which batoid remains of the various families and genera have been reported.

25. This diversity of opinion may be illustrated by the following examples: Regan (Proc. zool. Soc. Lond., 1906: 723–724), regarding the batoids only as a suborder (Hypotremata), proposed two "Divisions," the Narcobatoidei with one family for the Electric Rays, the Batoidei with two families for all other batoids. But later (Encyc. Brit., *24*, 1911: 596) he recognized seven families. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 257, 258), who classed them as a "division" of the Chondropterygia, defined six "Groups of Families" (Rhinobatoidei, Narcoidei, Raioidei, Dasybatoidei, Myloidei, and Mobuloidei). Jordan (Class. Fish., Stanford Univ. Publ. Biol., *3* [2], 1923: 102) divided the order Batoidei into three suborders: Sarcura with five modern families for the Saw- and Guitar-fishes and for the Skates, Narcaciontes with one family for the Electric Rays, and Masticura with five modern families for the Sting, Butterfly, Eagle, Cow-nosed, and Devil Rays. Bertin (Bull. Inst. océanogr. Monaco, *775*, 1939: 19) includes all modern Elasmobranchs in a single order, Euselachii, distributing the Skates, Rays, and Sawfishes among four suborders (Squatinorajiformes, Rajiformes, Torpediformes, and Trygoniformes) with seven families, the modern Sharks among seven suborders. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 289–290) has classed the batoids as an order (Rajae) with four primary subdivisions (Rhinobatoidei, Torpedoidei, Rajoidei, and Myliobatoidei). Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 245) treat the batoids as a "super order" (Platosomeae) consisting of two orders: Narcobatea, with one family, for the Electric Rays; and Batea, with three "superfamilies," Rhinobatoidea, Rajoidea, and Dasybatoidea, each having two, one, and four families respectively. Fowler has recently followed them in ranking the batoids as a superorder, though he has given them the name Rajioidea (Notul. Natur. Acad. nat. Sci. Philad., 187, 1947: 13). Finally, Berg, in his Classification of Fishes (Trav. Inst. Zool. Acad. Sci. URSS, *5* [2], 1940, and lithoprinted ed. 1947: 139 [Russ.], 381 [Eng.]), classes the batoids as an order, Rajiformes, which is divided directly into eight modern families and one fossil family, without the intermediary of any suborders.

in regarding them as sole members of one of the primary divisions, ranked here as a suborder (Torpedinoidea, p. 80). The thirty-odd species concerned have been united commonly in a single family, but they are distributed here among three families (for further discussion, see p. 86). The presence of horny rays (ceratotrichia) as well as of cartilaginous radials in their unpaired fins (a shark-like character) relates them more nearly to the rhinobatoids than to any other batoids.

The batoids that remain after the subtraction of the Electric Rays fall in four fairly well definable groups of species, classed here as suborders.

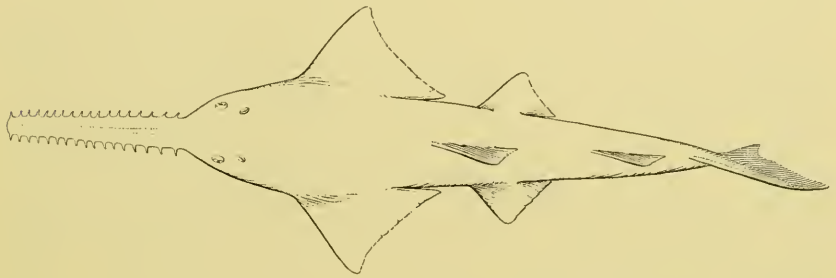

FIGURE 2. *Pristis perotteti*, juvenile male, about 1,376 mm long, from Lake Nicaragua (U. S. Nat. Mus. No. 120468).

A. The Sawfishes (Pristoidea). Snout prolonged as a narrow blade-like "saw," its either edge armed with a single series of large tooth-like structures; tail sector stout; two well developed dorsal fins, the first originating over or anterior to the pelvics; a large caudal fin; pectoral fins attached to head only a little past the gills; outer margins of pelvics straight or convex; the paired fins, as well as the unpaired, with horny rays (ceratotrichia) in addition to the cartilaginous radials.

B. The Guitarfishes (Rhinobatoidea). Snout not blade- or saw-like; tail sector stout; two well developed dorsal fins, the first originating much nearer to tips of pelvics than to tip of tail; a well developed caudal fin; pelvics with the outer margins convex, or at least not notched; their unpaired fins, like those of the Sawfishes and Torpedoes, have horny rays as well as cartilaginous radials, as do the unpaired fins of the Sharks, but not their paired fins.

C. The Skates (Rajoidea). Tail more slender and without spine; one or two small fins, or none; fins with cartilaginous radials only (no horny rays); the origin of first dorsal (if any) much nearer to tip of tail than to tips of pelvics; caudal fin reduced to a low fold finely striate in structure; the outer margins of pelvic fins more or less deeply concave. This group is typified by the common Skates.

D. The Rays (Myliobatoidea). Tail ranging from moderately to excessively slender; one dorsal fin or none; dorsal fin, if present, well forward on the tail, anterior to tips of pelvics or close behind them; pelvics with outer margins not concave; some

species with a well developed caudal fin (with cartilaginous radials) but others without one; fins without horny rays (ceratotrichia); in most species a strong serrated tail spine (or spines). This group includes the so-called Sting and Whip Rays, Butterfly Rays, Eagle Rays, and Devil Rays.

The dividing lines that separate the torpedinoids, the rhinobatoids, and the pristoids from the other suborders are sharp. But the gap between the rajoids and myliobatoids is partially bridged by one group, Anacanthobatidae (p. 327), in which the margins of the pelvics are as deeply notched as in most of the Rajoidea but in which the tail is diagnostic in that it is whip-like, without trace of a dorsal fin. It is classed here among the Rajoidea, but as a separate family (p. 327) because of its pelvics.

Number of Genera and Species. On the basis of present knowledge, the living representatives of the five suborders of batoids appear to be divisible into 16 families and about 47 genera. At present about 300–340 recognizable species have been described. A critical comparison of representatives of closely allied forms from different ocean areas doubtless will result in some condensation. But our own experience with the genera *Breviraja* (p. 284) and *Cruriraja* (p. 313) suggests that any reductions so caused will be more than counterbalanced by the discovery of new species from regions where the batoid fauna has been studied only casually, especially from the deeper levels along the continental slopes.

Key to Suborders

1a. Snout much prolonged as a flat narrow blade, its either edge armed with a single series of large tooth-like structures; radial cartilages of pectoral and pelvic fins supplemented distally by much more numerous fine horny rays, their inner ends embracing the outer ends of the cartilaginous radials. Pristoidea, p. 15.

1b. Snout not prolonged as a blade-like structure, its edges without teeth.

2a. Cranial support of anterior margin of disc consisting of a preorbital cartilage on either side, expanded forward, variously branched or reticulate (easily felt even in large specimens, though not visible externally), with one or two rostral elements also branched in some; skin of disc as well as of tail wholly naked in most species;[26] a highly developed electric organ on either side between head and forward extension of pectoral, often visible externally; tips of branchial rays expanded as rounded plates. Torpedinoidea, p. 80.

2b. A single rostral cartilage as a cranial support for anterior margin of head either present or not; electric organs, if any, rudimentary, on tail; skin in most species with scales, thorns, or spines; tips of branchial rays but little expanded, if at all.

3a. Tail sector so stout that it is not marked off definitely from body sector; dorsal and caudal fins well developed, supported distally by horny rays, basally by the cartilaginous radials. Rhinobatoidea, p. 43.

26. Described as having partly spinous papillae in one species (p. 92).

3b. Tail sector slender, extremely so in many cases, and sharply marked off from body sector; dorsal and caudal fins, if any, not supported distally by horny rays.

4a. Pelvis with prepelvic spur at outer corners; outer margin of pelvics concave in most; spiracles with traces of gill folds. Rajoidea. p. 132.

4b. Pelvis without spur at outer corners; outer margin of pelvics straight or convex; spiracles without trace of gill folds.

Myliobatoidea, p. 331.

Sequence of Presentation. The batoids as a whole constitute a highly specialized group, and the divergences between their major subdivisions represent still further specializations in one direction or another beyond their common divergence from the more generalized elasmobranch stem, as represented by the Sharks. Consequently it is not possible to represent the mutual interrelationships between the several suborders by any arrangement of them in linear series. Of the batoids, the Sawfishes (Pristoidea) are the most nearly shark-like in form of body; also, their fins, paired as well as unpaired, have horny rays (ceratotrichia) in addition to cartilaginous radials, as do the fins of Sharks. Although the saw of the Sawfish represents extreme specialization in one direction, this is almost exactly paralleled in the Saw Sharks (Pristiophoroidea). We, therefore, follow common usage in commencing this account with the Pristoidea, leading to the Rhinobatoidea. Also, it is customary to place the Myliobatoidea after the Rajoidea since they represent the extreme development of batoid specialization in general, and nothing would be gained by doing otherwise. Although the Electric Rays have been placed between the rhinobatoids and the rajoids,[27] between the rajoids and the myliobatoids,[28] or after the myliobatoids,[29] we place them immediately after the rhinobatoids, thinking their well developed unpaired fins, with horny rays in addition to the cartilaginous radials, more significant from the standpoint of relationships than the extreme specialization of their electric organs or the great development of their antorbital cartilages.

Suborder PRISTOIDEA

Sawfishes

Characters. General form more shark-like than ray- or skate-like, but with trunk and head flattened ventrally; the head especially flattened, its anterior part so strongly depressed as to be very thin dorsoventrally. No evident demarkation between body and tail sectors of trunk (Fig. 2). Snout extended as a long narrow flattened blade (the so-called "saw") armed along either edge with a single series of transverse teeth

27. See especially Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 257), Rey (Fauna Iberica, Peces, *1*, 1928: 515), and Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 332).

28. Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 27; Bertin, Bull. Inst. océanogr. Monaco, 775, 1939.

29. Berg, Classification of Fishes, Trav. Inst. Zool. Acad. Sci. URSS, 5 (2), 1940, and lithoprinted ed. 1947: 139 (Russ.), 381 (Eng.); Romer, Vert. Palaeont., 2nd ed., 1945: 577.

with persistently growing bases, each tooth representing a single enlarged dermal denticle;[30] these teeth are homologous not only with the rostral teeth of the Saw Sharks (Pristiophoroidea) but with the dorsal fin spines of *Heterodontus* and of some squaloid Sharks as well; rostral teeth deeply and firmly embedded in deep sockets of the hardened cartilage of the saw in all modern Sawfishes; however, in some fossil forms (genera *Propristis*, *Sclerorynchus*) they were not socketed but were seemingly attached to the skin only. The saw of the Sawfishes, while resembling that of the Saw Sharks (Pristiophoroidea) very closely in general appearance, does not bear the lateral cirri characteristic of the saw of the Saw Sharks. Anterior parts of pectorals fused with sides of head forward past all five gill openings and at a higher level, but not so far forward as the mouth; posterior corners of pectoral fins terminating considerably anterior to origin of pelvics. Origin of first dorsal varying from considerably anterior to origin of pelvics to a little posterior to rear ends of bases of latter. Second dorsal separated from first by a considerable interspace. Caudal well developed, either with or without definite lower lobe, its axis somewhat raised, with termination directed toward the rear margin of fin some distance below upper tip.

Eye with a rounded velum; orbit outlined below by a deep semilunar furrow, the skin of its lower half loose, described as acting like a nictitating (winking) membrane. Spiracles some distance posterior to eyes, oblique, their outer ends directed rearward (the reverse of what is usual among the batoids), their posterior margins without ridges or folds. Nostrils entirely separate from mouth and far removed from mouth, also from each other in the midzone; anterior margin expanded in a well marked lobe with rounded tip. Mouth transverse, nearly straight; skin at its corners wrinkled, but without well defined pits or furrows. Gill openings wholly on lower surface. Oral teeth small, rounded, close-set in quincunx arrangement and very numerous,[31] with several series in function simultaneously; tooth bands ovate to arcuate in cross section (Fig. 4K).

Dermal denticles over body as a whole minute, flat, ovoid, comparatively uniform, clothing the skin closely, including the saw; without larger thorns, tubercles, or spines.

The saw is supported by an elongate rostral projection from the cranium.[32] This cartilage encloses 3–5 longitudinal canals as well as other spaces toward its base, and it is strengthened by various calcifications, the entire outer layer immediately next to the integument being hardened in this way. Although the antorbital cartilages do not extend forward beyond the level of the nostrils, the anterior end of each is connected with the rostral cartilage by a ligamentous band.[33] Radial cartilages of paired as well as unpaired fins supplemented by much more numerous fine horny rays, the inner

30. For a detailed account of the histology and development of the rostral teeth, with references to earlier literature, see especially Engel (Zool. Jb., Anat. Abt. *29*, 1909: 51–100, pls. 3–6).

31. 70–178 series above and nearly as many below in the different species and at different stages in growth.

32. According to Gegenbaur (Unters. Vergl. Anat. Wirbelt., *3*, 1872: 91, pl. 9, fig. 7, 8), who has given the most detailed account with which we are acquainted, this rostral extension involves a single cartilage corresponding to the single rostral cartilage of the Rhinobatoidea, not three as had been believed earlier.

33. For a general account of the head skeleton and for a comparison with other groups of batoids, see Holmgren (Acta Zool. Stockh., *22*, 1941: 53, 64).

ends embracing the outer ends of the cartilaginous radials. Propterygial cartilages of pectorals as well developed as metapterygials. Pelvis convex in front but without processes directed forward from outer ends.[34] Surfaces of gill arches smooth inward from gill filaments.

Remarks. Attention has been called repeatedly to the shark-like features of the Sawfishes, i. e., to their elongated bodies, their powerful tails and caudal fins, and their comparatively small pectorals. Also, their mode of locomotion is shark-like, for they propel themselves through the water by powerful strokes of the rear part of the trunk and caudal fin, seemingly using the pectorals for steering and especially for directing their course upward toward the surface or downward toward the bottom. All their fins, like those of Sharks, have horny rays as well as cartilaginous radials. But their underlying structure is batoid—the fusion of their pectorals with sides of the head past the gill openings, the lack of free eyelids, the union of several of their anterior vertebrae which bear a wide lateral wing on either side in some, the presence of a scapular cartilage connecting the two ends of the pectoral girdle across the upper side of the vertebral column to which it is bound firmly by ligamentous tissue, the presence of many more radial cartilages on the propterygial cartilage of the pectoral fins than on the mesopterygial cartilage, and the fact that the lower jaw has no direct connection with the ceratohyal cartilage.[35]

The pristoids, in short, are true batoids, just as the squatinoids are true Sharks though batoid in general appearance. The saw of the Sawfish is a remarkable development, however, for its only counterpart in the entire vertebrate series is the similar structure developed by the Saw Sharks (Pristiophoroidea).

Development. Ovoviviparous; in at least one species there are several embryos within a single egg capsule in each uterus.[36] The rostral blade, at first more or less soft and flexible, is developed during the later embryonic stages; it has been known for more than two centuries that its lateral teeth do not project through the enclosing integument until after the young are set free,[37] otherwise it would hardly be possible for the mother to give birth to them. But the saw becomes calcified and the teeth grow very rapidly after the young commence their independent existence.[38] For example, in a 675 mm specimen of *Pristis pectinatus* (newborn to judge from its umbilical scar) the blade is already rigid, with the tips of the teeth slightly projecting, while in a *P. perotteti* of 865 mm (Fig. 6 A) the teeth are already about as long, relatively, as they are in the adult of that species.

Families and Genera. The modern members of the suborder resemble one another so closely that they are all referred by common consent to the Pristidae.

34. For further skeletal details, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 55, fig. 3; pl. 64, figs. 2–3).
35. For excellent illustrations of these skeletal characters, which we have verified by dissection, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 55, fig. 3, pl. 64, figs. 2, 3).
36. In a specimen of *Pristis cuspidatus* each uterus had a single egg capsule divided into four compartments, each with one embryo. See Setna and Sarangdhar [Rec. Indian Mus. (1948), *46* (1–4), 1949: 11, fig. 4].
37. "In the embryo state the sides of the snout are as smooth as the gums of a new-born infant" (Latham, Trans. Linn. Soc. Lond., Zool. *2*, 1794: 274; transl. from Klein, Hist. Pisc. Natural., *Missus 3*, 1743: 12).
38. This seems to have been remarked first by Latham (Trans. Linn. Soc. Lond., Zool. *2*, 1794: 274).

Family PRISTIDAE

Sawfishes

Characters. Those of the suborder.

Genera. All modern Sawfishes appear to fall within a single genus, *Pristis*. At most, the species in which a lower caudal lobe is developed have been given a separate subgeneric name.[39] The fossil pristids exhibit so wide a range of variation regarding calcification of the rostral blade and the implantation and other characters of the rostral teeth that a recent enumeration[40] lists not less than 12 genera. But it is likely that the number of these would be reduced considerably were material available for as critical a comparison of them as can be made for the modern Sawfishes.

Genus *Pristis* Link 1790

Sawfishes

Pristis Link, Mag. Physik. Naturg. Gotha, 6 (3), 1790: 31; Latham, Trans. Linn. Soc. Lond., Zool. *2*, 1794: 276; type species, *Squalus pristis* Linnaeus 1758.

Generic Synonyms.[41]

Pristibatus Blainville, Bull. Soc. philom. Paris (1816), 1816: 121; type species, *Pristis antiquorum* Latham 1794, equals *Squalus pristis* Linnaeus 1758, designated by Fowler (Bull. geol. Surv. N. J., 4, 1911: 81).

Pristibatys Blainville, Nouv. Dict. Hist. nat., ed. 2, 27, 1818: 385; emended spelling for *Pristibatus* Blainville 1816.

Pristibatis Blainville, in Vieillot, Faune Franç., 1825: 49; emended spelling for *Pristibatus* Blainville 1816.

Myriosteon Gray, Proc. zool. Soc. Lond., 1864: 163, 164; type *M. higginsii* Gray.[42]

Pristiopsis Fowler, Proc. Acad. nat. Sci. Philad., 57, 1905: 459; type species, *Pristis perotteti* Müller and Henle 1841;[43] subgenus for species with caudal having distinct lower lobe.

Generic Characters. Rostral teeth deeply embedded in calcified sockets,[44] nearly straight or slightly recurved and strongly compressed dorsoventrally, their tips sharp in newborn specimens but slightly blunted in older ones; both edges (anterior and posterior) sharp in young specimens, but the posterior edge more or less flattened, evidently by wear, in large ones; neither surface channeled, though both surfaces (dorsal and ventral) may be faintly striate toward the base. Each side of tail with a low longitudinal ridge. Dorsal fins with free rear corners considerably extended, as in many Sharks; the pectorals likewise. Caudal with or without a definitely outlined

39. *Pristiopsis* Fowler (Proc. Acad. nat. Sci. Philad., 57, 1905: 459).
40. Romer, Vert. Palaeont., 2nd ed., 1945: 577.
41. Fowler (Bull. U. S. nat. Mus., 100 [13], 1941: 290) includes among the synonyms of *Pristis* the fossil *Eopristis* Stromer (Beitr. Paläont. Geol. Öst. Ung., *18*, 1905: 52).
42. Based on a fragment that Gray thought might "indicate a new group of radiated animals nearly allied to *Asterias*"; but later it was identified by Günther (Cat. Fish. Brit. Mus., *8*, 1870: 436, footnote) as one of the lateral tubes of the saw of a *Pristis* that had become detached in some way.
43. The date of publication of Fowler's *Pristiopsis* for a Sawfish was August 14, 1905. Thus it antedates *Pristiopsis*, proposed by Schmidt (Stettin. ento. Ztg., 66 Jahrg., heft 2, 1905: 332) for Coleoptera, the date of publication being November, as printed on p. 384 of the stated publication.
44. This contrasts with their looser attachment to the blade in some fossil Sawfishes (p. 18).

lower lobe. Dermal denticles covering integument of saw similar to those on trunk. Characters otherwise those of the family.

Size. The ancients credited the Sawfishes with sizes equal to those of the Whalebone Whales, with which they were sometimes confused—for what reason one can hardly guess.[45] However, the ichthyologists of the eighteenth century were well aware that such stories had not the faintest justification. Sawfishes are among the larger of elasmobranchs, commonly growing to 15–16 feet in length; the larger species are reported as reaching 20–24 feet both in Indian and Australian waters[46] and in the Atlantic (p. 39), and we read that "individuals of 30 feet are sometimes encountered."[47]

When comparing the weights of Sawfishes with those of Sharks it is to be remembered that approximately $^1/_4$–$^1/_3$ of the over-all length of the former consists of the saw, which adds but little to the weight, while the head as a whole is so flattened dorsoventrally that it contributes much less to the weight than do the heads of most Sharks. On the other hand, the caudal fin occupies a smaller percentage of the total length than is the case in many Sharks. Thus, while a Sawfish probably would not weigh 600 pounds at less than about 14 feet, a Maneater (*Carcharodon*) might be expected to attain that weight at about eight feet, a Mako (*Isurus oxyrinchus*) at about nine feet, or a Greenland Shark (*Somniosus*) at about 11 feet. A Sawfish 17 feet $4^1/_2$ inches long weighed 1,300 pounds.[48] The heaviest of which we have found record, a West Indian female whose length was not recorded, was estimated to weigh 5,300 pounds.[49]

Habits and Food. Sawfishes are found in most warm seas and are plentiful locally. They live chiefly on bottom in shallow water where it is sandy or muddy, often close to the shore and perhaps seldom descending to a depth greater than five or six fathoms. They are most plentiful in sheltered bays or in estuarine situations, often in brackish water. They not only ascend far above tidal limits in large rivers in many parts of the world, but they are among the few elasmobranchs that are found regularly in fresh water, as in Lake Nicaragua where they appear to be landlocked (pp. 39, 40).

Sawfishes subsist chiefly on whatever small schooling fishes may be abundant locally, such as mullets and the smaller members of the herring tribe; they also feed to some extent on crustacea and other bottom-dwelling inhabitants. It is for the prosaic purpose of grubbing in the sand or mud in search of whatever prey they can uncover that the saw is chiefly used, the tips and posterior edges of its teeth often being more or less worn down in this way. They also use the saw to slash to and fro in schools of fishes, thus killing or stunning the victims, much as the swordfishes, sailfishes, and marlins use their swords. The sensational accounts of them as habitually attacking

45. Thus Pliny, according to Latham (Trans. Linn. Soc. Lond., 1794: 275), speaks of "Pristes" of 200 cubits length in the Indian Ocean.

46. Whitley, Aust. Mus. Mag., *3*, 1927: 23; Fish. Aust., *1*, 1940: 178.

47. Norman and Fraser (Giant Fishes, 1937: 60). An account has recently appeared of the capture in Panama Bay of a Sawfish said to have been 27 feet long (Mitchell-Hedges, Battles with monsters of the sea, 1937: 224–225). But its saw was described as being only a little more than five feet long, suggesting that the total length of the fish was overstated.

48. Baughman (Copeia, 1943: 44), a *Pristis perotteti* from Texas.

49. Norman and Fraser, Giant Fishes, 1937: 63.

whales have no basis.[50] Neither do we place any credence in reports that they customarily cut out and devour chunks of flesh from large fishes.

However, a large Sawfish does have a powerful weapon of defense—and potentially of offense—at its disposal in its saw, for it can strike sideways with the latter with great power, either in the water, as when being hauled alongside a boat, or on land if drawn up on shore. Consequently, even small ones should be handled or approached with caution, as every fisherman knows who is familiar with them. Since they may strike in the same way when lying on the bottom if disturbed, stories of injuries inflicted by them on fishermen or on bathers, or even of fatalities, cannot be brushed aside as imaginary.[51] But we know of no evidence of an unprovoked attack upon a bather in any part of the world by a Sawfish that had not been disturbed in some way.

Relation to Man. Sawfish flesh is coarse and, so far as we can learn, no regular use is made of it along the western coasts of the Atlantic except that one is occasionally exposed for sale in some tropical fish market. Indeed, it has been listed as poisonous in Cuba.[52] But small ones of three feet or so are described as "delicious as a breakfast pan fish."[53] And we read that in India "the flesh is equally esteemed with that of sharks. The fins are prepared and sent to China; the oil is extracted from their livers, whilst the skins are useful for sword scabbards or for smoothing down wood."[54] Sawfish saws are often offered for sale as curios in tropical ports, and they are still employed in religious ceremonies by the Australian natives. The skin is used to some extent for leather. But no attempt seems to have been made to obtain their skins or oil on a large scale, though a considerable yield of the latter per fish might be expected, judging from a recorded weight of $102^{3}/_{4}$ pounds for a single liver (length of fish not recorded).[55]

Sawfishes are too sluggish to be held in any regard as game fish by anglers. But they take cut fish-bait rather readily if they detect it (no doubt by scent). Once hooked they swim so powerfully, though slowly, and are so enduring, that the capture of a large one entails a long and often wearisome struggle. Also, it is not unusual for a Sawfish to leap clear of the water under such circumstances, as happened on one occasion when it required more than two hours for one of us to subdue a 14-foot Sawfish on a handline from a small boat.

Range. Tropical to subtropical coastlines, estuaries, and river mouths of all three great oceans, running up to fresh water in many localities. In the western Atlantic Ocean Sawfishes range northward regularly to the West Indies and Florida, seasonally

50. According to Lacépède (Hist. Nat. Poiss., 4° Edit., in Buffon, Hist. Nat., *1*, 1798: 292), there was in the Paris Museum part of a Sawfish saw that was said to have been taken from the side of a Whale. But there is no way of verifying this supposed origin.

51. A report received by Day (Fish. India, 1878: 728) of a bather in India being cut in two by a large one is not beyond the bounds of credence.

52. Hoffman, Rev. chil. Hist. Nat., 33, 1929: 29.

53. Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 28.

54. Day, Fish. India, 1878: 729.

55. See Hooper (Mem. Indian Mus., *2*, 1909: 59–60), who also gives chemical analyses of the oil of Indian Sawfishes, mixed, however, with that of Sting Rays and Sharks; see Marcelet (Bull. Inst. océanogr. Monaco, 817, 1942: 6) for analysis of liver oil from a Madagascar specimen.

to the Carolinas, occasionally to Chesapeake Bay, and accidentally to New Jersey; in the eastern Atlantic they occasionally range to the Mediterranean and as strays to Portugal. To the southward they occur to southern Brazil and northern Argentina in one side of the ocean and along tropical West Africa to the Cape of Good Hope in the other.[56] Their range elsewhere is extensive also: in the eastern Pacific from northern Mexico to Ecuador; in the west from Indo-China to Queensland and south seasonally to New South Wales (Sydney), including the East Indies; the tropical coasts of the Indian Ocean as a whole, including the Arabian Sea, south to the Islands of Reunion and Madagascar and to Natal; and the Red Sea. It is probable that the failure of scientific literature to report their presence for any of the island groups of the western tropical Pacific chiefly reflects the imperfection of the published record.

Species. The species of *Pristis* are separable into two groups according to whether the caudal has a distinct lower lobe or not. This distinction is used, in fact, as the basis for subgeneric separation in the most recent synopsis of the Sawfishes of the western Pacific-Indian Ocean.[57] The positions of the first dorsal relative to the pelvics and of the second dorsal relative to the caudal are characters of specific value. The number of rostral teeth, a character that is fixed before birth, also differs in different species.

The group in which the caudal fin has a lower lobe is represented in the western Atlantic by one species with 16–19 pairs of rostral teeth; this appears to be identical with the Sawfish described as *Pristis perotteti* from Senegal, West Africa, in 1841 by Müller and Henle. *P. zephyreus* Jordan and Starks 1895 of the Pacific Coast of Central America appears not to be separable from it, except perhaps by a slightly larger average number of teeth (p. 41). And *P. perotteti* is closely allied to the form that has been reported repeatedly as *P. microdon* Latham 1794 from various localities in Australian waters, from Indo-China, from the East Indies, from the Indian Ocean, and recently from India as *P. perotteti*.[58] The lower caudal lobe is still more prominent in *P. cuspidatus* of the western Pacific and Indian oceans; and *P. leichhardti* Whitley 1945,[59] recently described from Australia, also has a distinct lower caudal lobe.

The group lacking a lower caudal lobe is similarly represented in the western side of the Atlantic (so far as is known) by only a single species. This has usually been referred to *P. pectinatus* Latham 1794 because of its numerous rostral teeth (25–32 pairs) and it is so named here. A form resembling it closely in number of teeth and in relative positions of fins has been reported under this same name from the Pacific Coast of Central America, from South Africa, from the Indian Ocean and Red Sea, and from the Philippines. Here again the true relationship of the Atlantic to the Indian Ocean form remains to be established.

It appears that the Atlantic Sawfish which Linnaeus, in 1758, named *Squalus pristis* (type species of the genus) also lacks a lower caudal lobe, for the illustration on

56. Günther (Cat. Fish. Brit. Mus., *8*, 1870: 438) lists one from the Cape.
57. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 291.
58. By Prater, J. Bombay nat. Hist. Soc., *41*, 1939: 435.
59. Aust. Zool., *11* (1), 1945: 44.

which he based the species shows none.[60] But its saw is credited in the original account with having only 16–20 teeth.

An adequate description of *P. pristis* is much to be desired, because this is the species, as type of the genus, with which all other members of *Pristis* must be compared eventually. To date the only definite locality records of specimens positively referable to it are for Senegal,[61] the Mediterranean (where it appears to have been confused with other Sawfishes), and perhaps Portugal. But watch should be kept for it in the American side of the tropical Atlantic. Two other members of the group without lower caudal lobe are known from the western Pacific-Indian Ocean area, *P. zijsron* Bleeker 1851 and *P. clavata* Garman 1913; both of them are separable from *P. pectinatus*, from *P. pristis*, and from each other, by the characters listed in the accompanying Key.

Key to Species

1a. Caudal fin with a definite lower lobe.

2a. Origin of first dorsal posterior to origin of pelvics; subcaudal lobe prominent.
cuspidatus Latham 1794.
Southeastern Asia, East Indies, Ceylon, and India to Red Sea.

2b. Origin of first dorsal considerably anterior to origin of pelvics; subcaudal lobe small (Fig. 5).

3a. Rear tip of second dorsal separated from origin of caudal by an interspace about half as long as base of second dorsal.
perotteti Müller and Henle 1841, p. 34.
Also *zephyreus* Jordan and Starks 1895, from the Pacific Coast of Central America, and *microdon* Latham 1794, from the West Pacific-Indian Ocean.[62]

3b. Rear tip of second dorsal reaching to origin of caudal.
leichhardti Whitley 1945.
Queensland, Australia (in rivers).

1b. Caudal fin without definite lower lobe.

4a. Origin of first dorsal over origin of pelvics, or anterior to latter.

5a. 25–32 pairs of rostral teeth. *pectinatus* Latham 1794, p. 23.

5b. 16–20 pairs of rostral teeth. *pristis* Linnaeus 1758.
Eastern tropical Atlantic, accidental in Mediterranean and perhaps to Portugal.

4b. Origin of first dorsal clearly posterior to origin of pelvics.

6a. 25–32 pairs of rostral teeth; outer corners of pectorals

60. LeCluse (Exoticorum libri decem . . . Animal. Plant . . . Petri Belloni, obs. . . . . ., 1605: 136); locality "in Oceano Occiduo."

61. Rochebrune, Act. Soc. linn. Bordeaux, (2) 6, 1882: 49, as *P. antiquorum* Latham 1794.

62. See discussion, p. 21.

rather broadly rounded; origin of first dorsal clearly posterior to midpoints of bases of pelvics; a large species, growing to upwards of 20 feet in length.

zijsron Bleeker 1851.
Cochin-China, Australia, East Indies, Ceylon, India, Gulf of Oman.

6b. 18–21 pairs of rostral teeth; outer corners of pectorals subangular, about a right angle; origin of first dorsal anterior to midpoints of bases of pelvics; said to be a small species, growing to about $4^1/_2$ feet. *clavata* Garman 1906.
Queensland, Australia; also reported from the Canaries.[63]

Pristis pectinatus Latham 1794

Common Sawfish

Figures 3, 4

Study Material. Immature male, 1,396 mm long, from off Galveston, Texas; six small specimens, male and female, 960–1,040 mm long, from the vicinity of Galveston, Texas; and one newborn male, 675 mm long, from Mobile, Alabama; also a saw from a 14-foot specimen (sex not recorded) from southern Florida, and a saw about three feet long from a female more than 12 feet long from Pascagoula Bay, Louisiana; all in the Museum of Comparative Zoology; female about 3 feet 7 inches long from the Indian River, Florida, in Chicago Museum of Natural History.

Distinctive Characters. P. pectinatus is easily separable from the only other Sawfish (*P. perotteti*) known from the western side of the Atlantic by the following facts: its first dorsal fin originates about over the origin of its pelvics (considerably in front of origin of pelvics in *P. perotteti*); its caudal is much shorter, but broader relative to the length of the fin, with lower lobe only faintly indicated (cf. Fig. 3 with 5); its rostral teeth are more numerous, 24 or more on each side (not more than 19 or 20 in *P. perotteti*, but see p. 43, fn. 100); its saw is relatively somewhat shorter; its second dorsal has the posterior margin much less deeply concave; and its pectorals are smaller. It agrees with *P. pristis* of the eastern Atlantic in the shape of its caudal and in the position of the first dorsal fin relative to the pelvics, but it is separable from *P. pristis* by its more numerous rostral teeth (see Key, p. 22).

Description. Proportional dimensions in per cent of total length. Female, 1,017 mm,

63. *Pristis clavata* closely resembles *P. zijsron*, but the differences in number of rostral teeth, in the shape of the pectorals, and in the position of the first dorsal relative to the pelvics seem sufficient for specific recognition. We should point out, however, that Garman's (Bull. Mus. comp. Zool. Harv., *46*, 1906: 208; Mem. Harv. Mus. comp. Zool., *36*, 1913: 264) characterization of its second dorsal as smaller than its first might be misleading, for the linear dimensions of the two fins of the type specimen, which we have examined, are in the proportion of only about 1.1 to 1. It has been reported from Australia by Whitley (Fish. Aust., *1*, 1940: 178) also; and from the Canaries by Bellon and Mateu (Notas Inst. esp. Océanogr., [2] *53*, 1931: 28) from a dried specimen with 21 saw teeth.

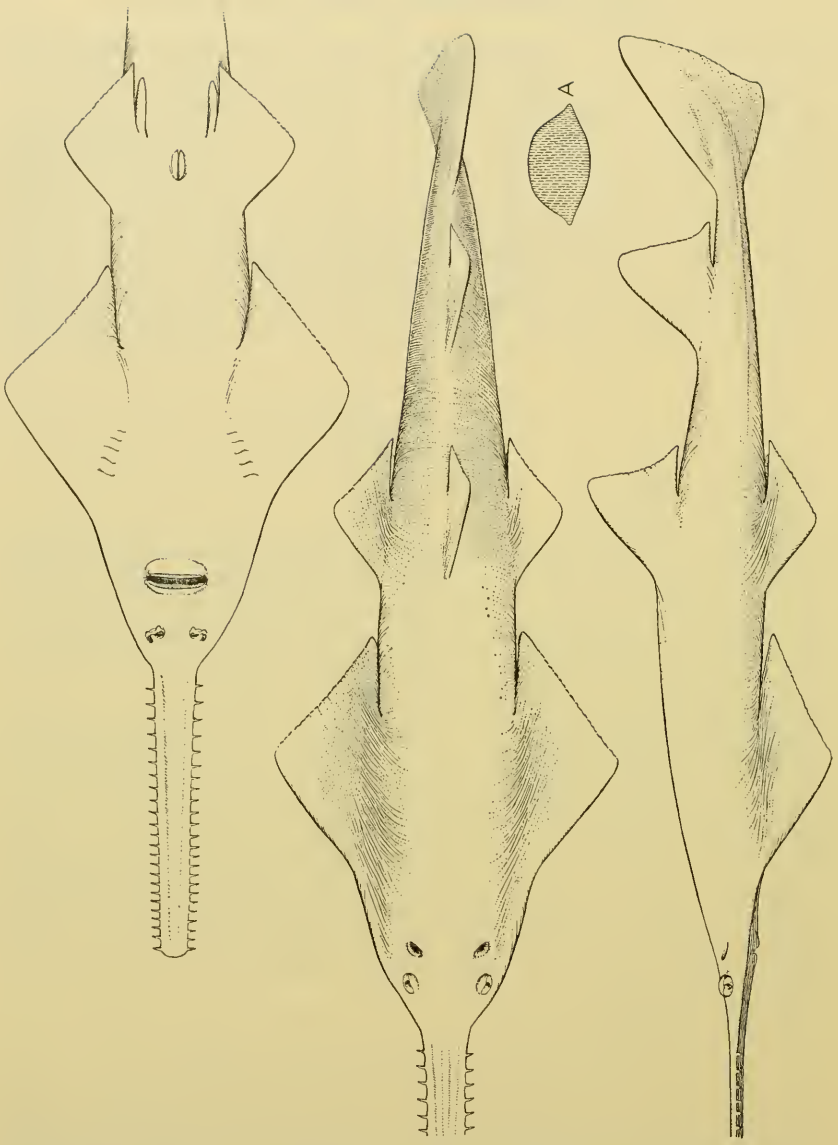

FIGURE 3. *Pristis pectinatus*, juvenile male, about 1,396 mm long, from off Galveston, Texas (Harv. Mus. Comp. Zool., No. 36659). *A* Cross section of caudal peduncle close in front of caudal fin, about 0.35×.

from Galveston, Texas (Harv. Mus. Comp. Zool., No. 36960). Male, 1,396 mm, from Galveston, Texas (Harv. Mus. Comp. Zool., No. 36659).

Breadth: between outer corners of pectorals 26.5, 26.6.
Snout length: in front of orbits 27.4, 25.4; in front of mouth 31.2, 28.9.
Orbits: horizontal diameter 1.9, 1.8; distance between 4.9, 4.7.
Spiracles: length 1.9, 1.6; distance between 4.0, 4.2.
Mouth: breadth 5.4, 5.1.
Nostrils: distance between inner ends 2.2, 2.0.
Gill openings: lengths, 1st 1.5, 1.6; 3rd 1.6, 1.7; 5th 1.2, 1.1; distance between inner ends, 1st 9.8, 10.1; 5th 7.2, 7.4.
First dorsal fin: vertical height 6.8, 6.8; length of base 7.0, 7.1.
Second dorsal fin: vertical height 6.8, 7.6; length of base 6.0, 6.4.
Caudal fin: upper anterior margin 15.0, 15.0; lower anterior margin 8.7, 8.7.
Pelvics: anterior margin 7.2, 7.5.
Distance from tip of snout to: 1st dorsal 58.9, 55.8; pelvics 58.8, 55.3; center of cloaca 62.0, 59.6; from center of cloaca to lower caudal 24.9, 26.5.

Trunk tapering nearly evenly rearward from level of axils of pectorals; flattened below; its height a little less than its width at origin of first dorsal where highest; its breadth at origin of pectorals between $^1/_4$ and $^1/_5$ as great as its length from base of saw to origin of caudal; a low fleshy ridge low down along either side from about opposite origin of second dorsal to opposite anterior part of caudal axis. Pectorals with nearly straight margins, narrowly rounded outer corners, and slightly blunted posterior corners, their anterior margins about as long as distal margins and directed outward much less abruptly from sides of head than in *P. perotteti* (cf. Fig. 3 with 5). Extreme width across pectorals about equal to distance from mouth to level of rear corners of pectorals, therefore considerably less, relatively, than in *P. perotteti* (p. 36). Caudal peduncle, at upper origin of caudal, about 1.5 times as wide as deep.

Minute dermal denticles closely covering skin everywhere (a shark-like character); those on upper surface of trunk and fins blunt ovate, varying in size one to the next, averaging smallest on outer parts of fins and on head anterior to eyes; blades nearly horizontal so that skin is only slightly rough to the touch; pedicels low. Denticles on lower surface smaller, varying considerably in size and in shape from roughly circular to blunt ovate or subpolygonal with rounded corners; without definite pedicels; so closely crowded that skin is visible only here and there; and lying so flat as to be smoother to the touch than those on upper surface. Denticles along midzone of saw of about same size as those on lower surface of trunk, but those along its edges considerably larger; extreme margin of saw naked in newborn specimens but completely covered with denticles by the time a length of about 1,400 mm or so is reached, if not sooner.

Saw about $^1/_4$ of total length in grown specimens; about $^1/_7$–$^1/_8$ as wide at base as long, narrowing evenly forward to only a little more than half (about 0.6) as wide

at tip as at base; weakly rounded above as well as below, and about $^1/_5$ as thick as broad; its tip rounded-truncate.

Rostral teeth 24–32 on either side, often one more tooth on one side than on the

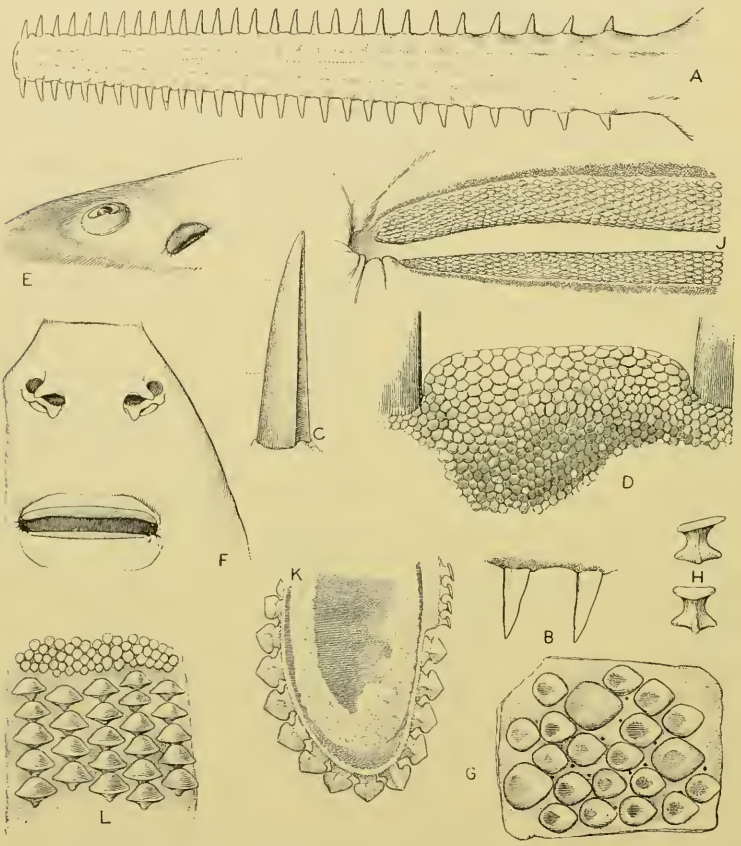

FIGURE 4. *Pristis pectinatus*. *A* Saw from specimen about 14 feet long, from southern Florida (Harv. Mus. Comp. Zool., No. 1220). *B* Two saw teeth from same, about 0.6×. *C* Saw tooth from same, seen obliquely, about 1.2×. *D* Margin of saw of same to show dermal denticles, about 5×. *E* Eye and spiracle of juvenile male, 1,396 mm long, from off Galveston, Texas (Harv. Mus. Comp. Zool., No. 36659), about 0.4×. *F* Lower surface of head of same, 0.4×. *G* Dermal denticles of same from below first dorsal fin, about 28×. *H* Dermal denticles from same in lateral and rear views, about 28×. *J* Right-hand half of upper and lower jaws to show tooth bands, about 1.8×. *K* Transverse section of upper jaw to show transition from dermal denticles on upper lip (smaller) to teeth (larger), with lateral aspect of latter, about 7×. *L* Teeth from central part of upper jaw, with dermal denticles on upper lip, about 7×.

other;[64] final number of teeth established at birth or soon thereafter; saw teeth spaced 5–6 times as far apart near base of saw as toward tip but with the decrease in spacing somewhat irregular;[65] the basal pair separated from the apparent level of emergence of the saw by a distance about as great as length of orbit. Individual teeth shortest but broadest (about 1.5 times as long as broad) at base of saw, narrower and longer both relatively and absolutely along terminal half, where they are about four times as long as broad; the longest teeth a little less than half as long as distance between nostrils; teeth with longitudinal axes about transverse to axis of saw as a whole, their posterior outlines a little more convex toward tips which are sharp or variously blunted by wear; anterior edge sharp; posterior edge flat transversely, or nearly so, on basal teeth but more or less channeled longitudinally farther out on saw, perhaps as result of wear, thus giving each tooth two longitudinal cutting edges posteriorly.

Head from base of saw to level of first gill opening between $^1/_5$ and $^1/_4$ (about 23 %) of trunk from base of saw to origin of caudal; its dorsal profile weakly convex; distance from anterior margins of orbits to base of saw about half as great as distance between orbits, and distance from mouth to base of saw a little greater than breadth of mouth. Orbits and spiracles of about equal lengths and a little longer than nostrils. Gill openings with anterior outlines strongly convex; breadth between inner ends of fifth pair a little greater than length from mouth to base of saw. Nostrils with anterior margin expanded as a narrow lobe with rounded tip directed rearward across mid-sector of nasal aperture; the posterior margin also forming two shorter lobes. Mouth transverse, nearly straight, its breadth about twice as great as distance between nostrils, with irregular folds at corners allowing wide gape.

Oral teeth $\frac{88-128}{84-176}$, minute, and dome-shaped anteriorly, with obtuse transverse cutting edge and base extended posteriorly in characteristic form (Fig. 4 L); close-set in quincunx along each jaw, in a band nearly semicircular in cross section, with about 10–12 rows in function simultaneously.

The two dorsals similar in shape and of about equal size; subtriangular; anterior margins weakly convex toward apex, posterior margins moderately concave toward base, free rear corners about half as long as bases, vertical heights about equal to distance between outer ends of spiracles or a little greater; origin of first dorsal about over origin of pelvics. Interspace between first and second dorsals about 1.5 times as long as base of first dorsal. Interspace between second dorsal and origin of caudal a little shorter than base of second dorsal. Caudal subtriangular with narrowly rounded corners, its upper margin nearly straight and about as long as distance from origin of second dorsal to midpoint of base of first dorsal; lower margin weakly convex, posterior margin slightly sinuous, with lower posterior corner projecting only slightly.

64. 25–26 in newborn male; 24–24, 24–25, and 25–25 on 30-inch specimens from Marco, Florida; 24–24 on male 1,420 mm; 26–27 on 14-foot specimen from Key West, Florida; and 28–28 on saw of one more than 12 feet long, among those that we have seen. A specimen apparently of this species has been recorded as having only 22 teeth on one side but 25 on the other (Bloch, Naturg. ausländ. Fische, 1, 1785: 42).

65. On two large saws, each about 640 mm long, the widest spacing (basal pair) is about 56 mm, the narrowest, a few pairs posterior to the tip, is only about 10 mm.

Pelvics about as long from origin to rear tip as interspace between dorsals; anterior margins nearly straight; corners abrupt.

Color. Nearly uniform dark mouse gray to blackish brown above, paler along margins of fins. White to grayish white or pale yellow below.

Size. The Common Sawfish is about two feet long at birth. It is known to reach a length of about 18 feet, perhaps even more.[66] Most of the individuals that wander northward along the Atlantic Coast of the United States to North Carolina and beyond are large. Thus the smallest of nine specimens taken on Cape Lookout Shoals was 12½ feet long, while others as long as 16 feet, and none very small, have been reported from estuarine waters of North Carolina. One taken off Ocean City, Maryland, was 10 feet long; the two so far reported from New Jersey were 16 feet and 16 feet 3 inches; the most northerly record of all, from the vicinity of New York, was for one of 15 feet. A female of 15 feet has been found to contain embryos, but the size at which they first breed is not known for either sex. One 12½ feet long was reported as weighing 425 pounds; another of about 16 feet, 700 pounds.

Developmental Stages. Embryos, so young that they still bear the large yolk sac, already resemble their parents as regards relative position of fins and absence of lower caudal lobe; however, the posterior edges of the dorsals do not assume their characteristic concavity until near the time of birth. Their saws, like those of other embryonic Sawfishes, are soft and leathery previous to birth, and the rostral teeth are also soft and entirely enclosed in the skin until birth, while a narrow band along each margin of the saw is naked, both below and above. But the teeth attain their full size proportionate to the size of the saw, and the margins of the latter become completely clothed with denticles soon after the young are set free. Gravid females have been found with 15–20 embryos.

Habits. This species, like other Sawfishes, is almost exclusively restricted to the immediate vicinity of the land and to water only a few feet deep. Indeed, we once had the rather startling experience of striking a Sawfish of 12–14 feet with the bottom of our boat when rowing in water only about three feet deep near Key West, Florida. And we have seen another large one swimming there in water so shoal that its dorsal fins were above the surface. It is most often encountered in partially enclosed waters, lying in the deeper holes on bottoms of mud or muddy sand, and it frequents brackish water as often as water of oceanic salinity. It has long been known to run up into fresh water regularly, perhaps to remain there permanently, as in the lower reaches of the Amazon, in the Essequibo in British Guiana, in the Atrato and San Juan rivers of Colombia (tributary to the southwestern Caribbean), in the lower Mississippi, and in the St. Johns River, Florida, which they are said to ascend to Jacksonville.[67] On the other hand, such specimens as wander northward in summer along the southeastern United States

66. The maximum recorded length with which we are acquainted is 18 feet 1¾ inches (vaguely rumored up to 20 ft.), while specimens of 12–16 feet have been reported repeatedly.

67. A landlocked population of this species may exist in Lake Nicaragua, where the existence of two kinds of Sawfishes has been reported (Marden, Nat. geogr. Mag., *86*, 1944: 184; and personal communication from Jose Arguillo Gomez).

necessarily follow the outer coast for at least the major part of their journeys. To reach Bermuda, as a few certainly do from time to time, they must cross at least 600 miles of open ocean. To judge from the latitudinal limits within which they are year-round residents and from the summer-winter temperatures of the Carolinian waters that they visit during the warm half of the year, the lower thermal limit to their normal range is probably about 16–18° C (60–65° F); the upper limit may even be as high as 30° C (86° F).

P. pectinatus, like its relatives, obtains its prey of various small animals chiefly by stirring the mud with its saw, and it may often be seen while so employed. The motion of the saw is described by an eyewitness as principally backward and forward.[68] But they are recorded also as playing havoc among schools of small mullets and clupeoids, slashing sidewise at them with their saws and devouring the wounded victims. They bite a hook freely if it is baited with fresh fish.

The fact that young are abundant off Texas, with specimens of three feet or smaller being much more plentiful than larger adults both along the west coast of Florida and in the Indian River on the east coast, is good evidence that large numbers of young are born at least that far northward, as well as along the coasts of British and French Guiana[69] to the southward by similar evidence. The presence of small ones in greater numbers than adults up the St. Johns River makes it likely that young are not only produced in fresh water but that they thrive there. But there is no reason to suppose that any young that may be produced by stray females north of Florida would survive the cold of the succeeding winter.

Gravid females, with embryos far advanced in development, have been taken in southern Florida waters in April and in July, and small free-living specimens have been caught there in January, suggesting that the young are set free in that region from late spring through the summer, and perhaps through the autumn. The presence of "young" specimens in abundance off southern Texas in May and June[70] and in July near Galveston[71] is in line with this conclusion, for it is not likely that any born there in autumn would grow much during the first winter. Farther south, where the seasonal range of temperature is narrower and where the winter temperatures are considerably higher, it is likely that young are produced throughout the year.

It has been suggested that the period of gestation is about one year,[72] but available information is not sufficient to establish this point.

Numerical Abundance. The Common Sawfish is so plentiful in Florida waters that an eyewitness writes of seeing hundreds of them, "big and little,"[73] on the west coast of the peninsula, and one fisherman reports the accidental capture of 300 in his nets in the Indian River in a single season.[74] Many small ones are caught by fishermen

68. Henshall, Bull. U. S. Fish Comm., *9*, 1891: 372.
69. Müller and Troschel, in Schomburgk, Reisen Brit. Guiana, *3*, Fauna Flora Brit. Guiana, 1848: 642; Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 89.
70. Baughman, Copeia, 1943: 45.
71. See Study Material, p. 23.
72. Nichols, Bull. Amer. Mus. nat. Hist., *37*, 1917: 876.
73. Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210.
74. Evermann and Bean, Rep. U. S. Comm. Fish. (1896), 1898: 239.

along the coast of French Guiana,[75] and it is common along the south coast of Cuba.[76] Definite information is lacking, however, as to its numerical status elsewhere.

Relation to Man. The Common Sawfish is of no commercial value anywhere in the western Atlantic, though small ones have been described as being delicious pan fish and the larger ones as yielding good steaks. But they are of considerable concern to fishermen as nuisances because of the damage they do to drift- and turtle-nets, to seines, and to shrimp trawls in which they often become entangled and because of the difficulty of disentagling them without being injured by their saws (p. 20).

A few are occasionally caught, incidentally, by anglers with hook and line, while some are harpooned. A large one puts up a powerful and dogged resistance, often towing a small boat for a considerable distance, as we know from experience (p. 20). But they are so slow-moving when hooked that few would rank them as worth special pursuit as game fish.

Range. Tropical-subtropical Atlantic, north and south; equatorial West Africa to the Mediterranean in the east;[77] regularly in the west from mid-Brazil to the northern shores of the Gulf of Mexico and to northern Florida; to North Carolina as a summer visitor; less often to Chesapeake Bay; and as a rare straggler to New Jersey and the vicinity of New York. It is represented on the Pacific Coast of Central America (p. 21), and also in the corresponding latitudinal belt of the western Pacific and Indian oceans and in South African waters,[78] by close relatives, but their precise relationship to *P. pectinatus* of the North Atlantic is still to be determined.

Occurrence in the Western Atlantic. The localities of definite record for *P. pectinatus* are distributed widely enough to show that it is of general occurrence in estuarine situations and in the lower reaches of rivers, as well as along open coasts fronted by mud flats. Its range extends from middle Brazil northward along the South American Coast, throughout the Caribbean-West Indian region in general, around the western and northern shores of the Gulf of Mexico, and along both coasts of Florida,[79] northward on the east coast to the Indian and St. Johns rivers.

On the Atlantic Coast it is a year-round resident to northern Florida. Northward beyond that it is known only as a summer visitor. Small numbers appear yearly on the

75. Puyo, Bull. Soc. Hist. nat. Toulouse, 70, 1936: 89. 76. Personal communication from Luis Howell-Rivero.

77. It has long been appreciated that old reports of Sawfishes frequenting high latitudes, and of *P. pectinatus* in particular being near Spitzbergen (Bloch, Naturg. ausländ. Fische, 1, 1785: 42), had no basis in fact; we fancy that they lead back to confusion with the Narwhal.

78. Sawfishes from South Africa have been reported recently by Barnard (Pict. Guide S. Afr. Fish., 1948: 22) and by Smith (Sea Fish. S. Afr., 1949: 63) under this name.

79. Reported from Santos, Natal, and in fresh water from Para, in Brazil; from French and British Guiana; from fresh water in the Essequibo River; from the Island of Trinidad and Venezuela; from the Atrato and San Juan rivers in Colombia; from Martinique, Curaçao, Puerto Rico, Haiti, Jamaica (personal communication from Luis Howell-Rivero), and both coasts of Cuba; from the vicinity of Matamoros on the Gulf Coast of Mexico near the Texas border; along the Texas Coast in the Gulf of Mexico from off Laguna Madre in the south to the vicinity of Galveston in the north; from various passages and bayous along the Louisiana Coast; from Lake Ponchartrain and the lower Mississippi River, where it was said long ago to ascend to the Red River of Arkansas (Rafinesque, Ichthyol. Ohiensis, 1820: 86); from Bimini, Bahamas (personal communication from C. M. Breder, Jr.), and from many localities around the coasts of Florida, from Pensacola in the west to the Indian and St. Johns rivers in the east. It is also listed from Rio de Janeiro (doubtfully), and from northern Argentina, Lat. 38° S (Pozzi and Bordale, An. soc. cient. argent., 120, 1935: 152), but we have found no supporting evidence that it ranges that far south.

shoals off Cape Lookout, and some have been said to visit the sounds and brackish rivers along the coast of North Carolina,[80] though this perhaps calls for verification.[81] A few even pass Cape Hatteras to enter the lower part of Chesapeake Bay, where one or two are sometimes taken in a year, but sometimes none. Stray specimens, all large, have been recorded also from Ocean City, Maryland, from the southern part of the New Jersey Coast, and one from the vicinity of New York more than a century and a half ago,[82] this last being the most northerly record (backed by good evidence) for it on the Atlantic Coast of America.[83]

It is also known to occur occasionally around Bermuda, where a small one was found in the stomach of a dolphin; a second, with a saw 18 inches long, was taken near St. Davids; and a third (large) has been reported as seen.[84] But it is not likely that there is a locally maintained stock of Sawfishes in Bermudan waters, otherwise they would be reported more frequently there.

Synonyms and Atlantic References:[85]

Saegefisch, Bloch, Naturg. ausländ. Fische, *1*, 1785: 41, pl. 120 (descr., ill., embryo, saw, ident. by no. of teeth and position of first dorsal; Brazil, but ref. to Spitzbergen erroneous, see p. 30, fn. 77).

Pes de Espada, Parra, Descr. Piez. Hist. Nat. Havana, 1787: 75, pl. 33 (descr., ill., Cuba).

Le Squale Scie, Lacépède, Hist. Nat. Poiss., 4° Ed., in Buffon, Hist. Nat., *1*, 1798: 286, pl. 8, fig. 4 (descr., ident. by no. sawteeth and fins, coast of Africa, but other species perhaps included); and in Sonnini, Hist. Nat. Poiss., *4*, 1801–1802: 128 (descr., size).

Squalus pristis Bonnaterre, Tabl. Encyc. Meth. Ichthyol., 1788: 11, pl. 8, fig. 24 (diagn., ill., ident. by no. sawteeth, fins, size; Europ. Ocean); Schöpf, Beschreib. nordamer. Fische, Schr. Ges. Naturf. Freunde Berlin, *8*, 1788: 185 (15-ft. specimen, New York, 1782, ident. by no. sawteeth).

Pristis pectinatus Latham, Trans. Linn. Soc. Lond., *2*, 1794: 278, pl. 26, fig. 2 (descr., ill. of saw, "Hab. in Oceano," doubtless Atlant.); Bloch and Schneider, Syst. Ichthyol., 1801: 351, pl. 70, fig. 1 (descr., ill. labelled "*P. serra*," "in Oceano"); Lacépède, Hist. Nat. Poiss., 4° Ed., in Buffon, Hist. Nat., *4*, 1801–1802: 680 (other species considered varieties); Risso, Ichthyol. Nice, 1810: 22 (listed, Nice, Italy); Cuvier, Règne Anim., *2*, 1817: 131, ftn. 4 (ref. to Latham, 1794); Blainville, in Vieillot, Faune Franç., 1825: 51, pl. 12, fig. 3 (diagn., no. sawteeth, meas., color, France by ref. to Risso, 1810; ill. not seen); Risso, Hist. Nat. Europ. Merid., *3*, 1826: 141 (diagn., S. Europe); Müller and Henle, Plagiost., 1841: 109 (Cayenne specimen ident. by no. sawteeth, but other species perhaps included); Bonaparte, Cat. Pesc. Europ., 1846: 15 (included with query); Müller and Troschel, in Schomburgk (Robert), Reisen Brit. Guiana, *3*, Schomburgk (Rich.), Fauna Flora Brit. Guiana, 1848: 642 (size, Brit. Guiana); Gray, List Fish. Brit. Mus., 1, 1851: 90 (listed, Mexico, W. Indies, but refs. only in part and specimens from C. Good Hope and Calcutta perhaps not this species); Duméril, Hist. Nat. Poiss., *1*, 1865: 475, pl. 9, fig. 3 (descr., ill. of saw, Haiti, but Red Sea ref. perhaps not this species); Poey, Repert. Fisico-Nat. Cuba, *2*, 1868: 456 (diagn., nos., Cuba); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 437 (W. Indies, Mexico specimens, but refs. for Calcutta and C. Good Hope perhaps not this species); Brito-Capello, J. Sci. math. phys. nat. Lisboa, *4* (13), 1872: 88 (listed, Angola); Doderlein, Man. Ittiol. Medit., 2, 1881:

80. Smith, Bull. N. C. geol. econ. Surv., *2*, 1907: 39.
81. According to Gudger, it had never been taken in Beaufort Harbor (Proc. biol. Soc. Wash., *25*, 1912: 144).
82. By Schöpf, Beschreib. nordamer. Fische, Schr. Ges. Naturf. Freunde Berlin, *8*, 1788: 185.
83. A Sawfish, seemingly this species because of the number of rostral teeth, was included by Denys (Hist. Nat. Amer. Septent., 1672, as quoted by Cox [Bull. nat. Hist. Soc. New Brunsw., *3* (13), 1896: 29]) in early Colonial days in an enumeration of fishes from the southern side of the Gulf of St. Lawrence. But the saw in question probably had been brought as a curiosity from some southern port.
84. Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 30.
85. See Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 253–254) for references as *P. pectinatus* for the Pacific Coast of Central America; Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 291) for the western Pacific-Indian Ocean region.

108 (synonyms, descr., Medit. by ref. to Duhamel, 1782); Moreau, Hist. Nat. Poiss. France, *1*, 1881: 377 (descr., cf. other species, S. France, by ref. to Duhamel, 1782); Poey, in Gundlach, An. Soc. esp. Hist. Nat., *10*, 1881: 349 (listed, Puerto Rico, Mexico, Cuba, but ref. for Calcutta probably not this species); Goode and Bean, Proc. U. S. nat. Mus., *5*, 1882: 240 (listed, Gulf of Mexico); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 875 (diagn., *P. pectinatus* replaces *antiquorum*, Gulf of Mexico; ascending lower Mississippi R.); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Goode, Fish. Fish. Industr. U. S., *1*, 1884: 668, pl. 248 (nos., sizes, Florida Coast, St. Johns R.; C. May, New Jersey); Jordan, Proc. U. S. nat. Mus., *7*, 1884: 105 (Key West, Florida); Jordan and Swain, Proc. U. S. nat. Mus., *7*, 1884: 230 (listed, Cedar Keys, Florida); Jenkins, Johns Hopk. Univ. Circ., *5* (43), 1885: 11 (listed, Beaufort, N. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 798 (listed, W. Indies, S. Atlant. and Gulf States); Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 88, pl. 23 (mucous canals); Carus, Prod. Fauna Medit., *2*, 1889–1893: 515 (listed, Medit.); Henshall, Bull. U. S. Fish Comm., *9*, 1891: 372 (sizes, habits, nos., W. Florida); Evermann and Kendall, Bull. U. S. Fish Comm., *12*, 1894: 95 (listed, Galveston, Texas); Lönnberg, Oefvers. Svensk. Vet. Akad. Forh., *51* (3), 1894: 111 (listed Punta Gorda, Florida); Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210 (nos., size, feeding, Florida); Cox, Bull. nat. Hist. Soc. N. Brunsw., *3* (13), 1896: 29 (ref. to S. shore Gulf St. Lawrence, by Denys, 1672, doubtless erroneous; see p. 31); Evermann and Bean, Rep. U. S. Comm. Fish. (1896), 1898: 239 (size, nos., season, embryos, Indian R., Florida); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 60 (diagn., tropical, to W. Indies and Florida, Gulf of Mexico, lower Mississippi R.); Rep. U. S. Comm. Fish. (1895), 1896: 220 (listed, tropical, to W. Indies and Florida); Smith, Rep. U. S. Comm. Fish. (1895), 1896: 175 (listed, Biscayne Bay, Florida); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (3), 1898: 2749 (*P. zephyreus* considered distinct from *pectinatus*); Osorio, J. sci. math. phys. nat. Lisboa, (2) *5*, 1898: 201 (listed, Angola); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (W. and E. Florida); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (4), 1900: pl. 8, fig. 27 (ill., Pensacola, Florida); Wilson, Amer. Nat., *34*, 1900: 355 (listed, Beaufort, N. Carolina); Gregg, Where to Catch Fish, 1902: 23 (ill., listed, Florida); Evermann and Marsh, Bull. U. S. Fish Comm., *20* (1), 1902: 64 (size, nos., no. embryos, Indian R., Florida); Turner-Turner, Giant Fish. Florida, 1902: 190, 191 (habits, photo); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 80 (doubtfully listed, Rio de Janeiro); Werner, Zool. Jb., Syst. Abt., *21*, 1904: 293 (no. sawteeth), 294 (in Key); Hargreaves, Fish. Brit. Guiana, 1904: 14 (listed, Brit. Guiana); Jordan, Guide to Study Fish., *1*, 1905: 550 (in brackish water); Fowler, Proc. Acad. nat. Sci. Philad., *58*, 1906: 80 (listed, Florida Keys); Rep. N. J. Mus. (1905), 1908: 69 (listed, New Jersey, size); Ribeiro, Ann. Mus. nac. Rio de J., *14*, 1907: 173 (diagn., Brazil), 206 (refs.); Smith, Bull. N. C. geol. econ. Surv., *2*, 1907: 39 (diagn., ill., N. Carolina); Anon., Bull. N. Y. zool. Soc., *29*, 1908: 424 (function of saw); Regan, Biol. Cent. Amer. Pisces, 1908: 183 (listed, Mexico, Central America); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 469 (listed, Matamoros, Mexico, Essequibo R., Brit. Guiana); Vincent, Sea Fish. Trinidad, 1910: 52 (type of bottom, capture, Trinidad); Engelhardt, Zool. Anz., *39*, 1912: 648 (listed, Para, Brazil, fresh water); Gudger, Proc. biol. Soc. Wash., *25*, 1912: 144 (no. sawteeth, size, capture, C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 262 (descr., refs. in part); Halkett, Check List Fish. Canad., 1913: 42 (erroneously listed by ref. to Denys, 1672; see p. 31); Starks, Leland Stanf. Univ. Pub., Univ. Ser., 1913: 6 (listed, Natal, Brazil); Fowler, Copeia, 2, 1914: 2 (no. sawteeth, size, Ocean City, Maryland); Coles, Proc. biol. Soc. Wash., *28*, 1915: 92 (nos., size, C. Lookout, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *67*, 1915: 245 (listed, Ft. Pierce, Florida); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 268 (no. sawteeth, oral teeth, denticles, ills., C. Lookout, N. Carolina); Wilson, Ann. Carneg. Mus., *10*, 1916: 58 (listed, Georgetown, Brit. Guiana, perhaps Atrato R. and San Juan R. in the north, Colombia); Nichols, Bull. Amer. Mus. nat. Hist., 37, 1917: 876 (embryos, size, breeding season, S. Florida); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Santos, Brazil); Metzelaar, Trop. Atlant. Visschen, 1919: 7 (listed, Curaçao, W. Indies), 192 (listed, trop. W. Africa); Eigenmann, Indiana Univ. Stud., 46, 1920: 10 (listed, Atrato R., Colombia); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 145 (listed, C. May County, New Jersey, New York by ref. to Schöpf, 1788); Lahille, Physis B. Aires, *5*, 1921: 63 (listed, Argentina); Eigenmann, Mem. Carneg. Mus., *9*, 1922: 25 (listed, Quito R., Atrato Basin, Colombia); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 66 (no Panama record); Ribeiro, Fauna brasil., Peixes, *2* (1), Fasc. 1, 1923: 30, pl. 10

(diagn., good ills., Brazil); Breder, Bull. Bingham oceanogr. Coll., *1* (1), 1927: 5 (listed, W. Indian region); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 55 (descr., color, size, Chesapeake Bay); Rey, Fauna Iberica, Peces, *1*, 1928: 501 (ill.), 502 (in Key); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 27 (diagn., size, util., range); Jordan, Manual Vert. Anim. NE. U. S., 1929: 16 (genl.); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., *3*, 1929: 27 (diagn., listed Worcester County, Maryland, Chesapeake Bay); Nichols, Sci. Surv. Porto Rico, Spec. Publ. N. Y. Acad. Sci., *10* (2), 1929: 185 (listed, Porto Rico by ref. to Poey); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23 (in check list); Uriarte and Mateu, Notas Inst. esp. Oceanogr., (2) 53, 1931: 27 (nos. sawteeth, Canaries, Lagos, W. Africa); Gowanloch, Bull. La. Conserv. Dep., 21, 1932: 88, 89 (diagn., size, edibility, Louisiana); Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 30 (Bermuda); Gowanloch, Bull. La. Conserv. Dep., 23, 1933: 209 (feeding habits, Louisiana); Gudger, J. Elisha Mitchell sci. Soc., *49*, 1933: 59 (listed, C. Lookout, N. Carolina); Beltran, List. Peces Mexicanos, 1934: 10 (listed, Mexico; not seen); Gunter, Copeia, 1935: 39 (Louisiana); Pozzi and Bordale, An. Soc. cient. argent., 120, 1935: 152 (listed, Argentina, Lat. 38° S); Fowler, Bull. Amer. Mus. nat. Hist., 70 (1), 1936: 94 (diagn., size, ill., Mexico, Guiana, W. Indies; refs. for trop. W. Africa); Bull. Amer. Mus. nat. Hist., 70 (2), 1936: 1153 (listed, Canaries, Lagos, W. Africa by ref. to Uriarte and Mateu, 1931); Gunter, La. Conserv. Rev., 5 (4), 1936: 45 (Louisiana); Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 89 (sizes, nos., French Guiana); Smith, Biol. Rev. (Cambridge), *11*, 1936: 64 (listed, fresh water); Norman and Fraser, Giant Fishes, 1937: 60 (ill., range); Budker, Ann. Inst. océanogr. Monaco, *18*, 1938: 236 (scales, sensory pits, no local.); Gunter, Amer. Midl. Nat., *26*, 1941: 196 (Texas); Fowler, Arqu. Zool. Estad. São Paulo, *3*, 1942: 130 (listed, Santos and Natal, Brazil); Fish Culturist, *21* (9), 1942: 66 (listed, Cuba); Gunter, Amer. Midl. Nat., *28*, 1942: 312 (Texas); Baughman, Copeia, 1943: 43 (season, gravid females, young, Texas); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 264 (listed, Florida); Schultz, Proc. U. S. nat. Mus., *99*, 1949: 21 (no. saw teeth; Venezuela).

Pristis granulosa Bloch and Schneider, Syst. Ichthyol., 1801: 352 (no. sawteeth, by ref. to Parra, 1787).

Pristis serra Bloch and Schneider, Syst. Ichthyol., 1801: pl. 70, fig. 1 (ill.).

Pristis mississippiensis Rafinesque, Ichthyol. Ohiensis, 1820: 86 (descr., saw, young; listed, lower Mississippi to Red R., Arkansas, but rep. for Ohio R. probably erroneous).

Pristis antiquorum Owen, Odontogr., 1840–1845: pl. 8, fig. 1 (ill. of saw, sawteeth, oral teeth); DeKay, Zool. N. Y., 4, 1842: 365 (listed, New York, by ref. to Schöpf, 1788); Hall, 24th Ann. Rep. N. Y. St. Mus. (1870), 1872: 36 (listed New York by ref. to Schöpf, 1788); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 811 (listed, C. Cod to Florida); Yarrow, Proc. Acad. nat. Sci. Philad., 1877: 217 (Beaufort, N. Carolina); Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 190; 2nd ed., 1876: 160 (Chesapeake Bay); Goode, Proc. U. S. nat. Mus., 2, 1879: 120 (listed, E. Florida); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 37 (diagn., size, both shores Atlant.).

Pristis acutirostris Duméril, Hist. Nat. Poiss., 1, 1865: 479 (descr., ident. by nos. sawteeth and position of fins, Antilles); Bertin, Bull. Mus. Hist. nat. Paris, (2) 11, 1939: 78 (type specimen in Paris Mus., Antilles).

Pristis megalodon Duméril, Hist. Nat. Poiss., 1, 1865: 476, pl. 9, fig. 4 (descr., ill., saw, no local.); Bertin, Bull. Mus. Hist. nat. Paris, (2) 11, 1939: 78 (type in Paris Mus., Cayenne, French Guiana).

Pristis, no specific name, Shields, Amer. Nat., 13, 1879: 262 (16-ft., 700-pound specimen, Grassy Sound near C. May, New Jersey).

Probable synonyms:

Vivelle ou Poisson a Scie, Duhamel, Traité Pêches, 3, Sect. 9, 1782: 331, pl. 25, figs. 3–5 (reported S. France, but specimen ill. without stated local.).

Pristis occa Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 49; Faune Senegambie, *1*, Poiss., 1883: 26 (trop. W. Africa, doubtful if ident. with *P. occa* Duméril [Hist. Nat. Poiss., *1*, 1865: 479], no local.).

Pristis antiquorum Clarke, in Van Doren, Fish. Atlant. Coast, 1884: 156 (habits, size, Florida).

Pristis woermanni Fischer, Jber. Wiss. Anstalt. Hamburg (1883), *1*, 1884: 39 (no. sawteeth and fins as in *P. pectinatus*, but sep. because anterior sawteeth not spaced closer than posterior; Cameroon); Monod, Faune Colon. Franç., 1927: 648 (by ref. to Fischer, 1884; not seen).

Pristis typica Hoffman, Rev. chil. Hist. Nat., 33, 1929: 29 (no descr., Cuba, ident. probable because of local., listed as poisonous).

Pristis cuspidatus Fowler, Arqu. Zool. Estad. São Paulo, *3*, 1942: 130 (listed, Bahia de Rio de Janeiro (?), and Natal, Brazil, by erroneous refs. to Schreiner and Ribeiro, 1903 and to Starks, 1913).

Doubtful References:

Pristis pectinatus Miles, Peces Rio Magdalena, Ministr. Econ. Nac. Secc. Piscicult., 1947: 36, 37 (fresh water, Magdalena R., Colombia, 600 km from sea, but ident. doubtful because only 21/21 sawteeth).

Not *Squalus pristis* Linnaeus, Syst. Nat., *1*, 1758: 235 (E. Atlant.).

Not *Pristis antiquorum* Latham, Trans. Linn. Soc. Lond., *2*, 1794: 277, pl. 26, fig. 1 (equals *Squalus pristis* Linnaeus 1758).

Not *Pristis cuspidatus* Latham, Trans. Linn. Soc. Lond., *2*, 1794: 279, pl. 26, fig. 3.

Pristis perotteti Müller and Henle 1841

Southern Sawfish

Figures 2, 5, 6

Study Material. Two immature males, 862–956 mm long, from Para, Brazil, and a female of about 810 mm, from Marajó Island at mouth of Amazon River (Harv. Mus. Comp. Zool.); immature male, 1,376 mm long, from Lake Nicaragua; female, about 1,400 mm long, from Lake Yzabel, Guatemala, and two small saws, 301 and 309 mm long, from Lake Yzabel, Guatemala (U. S. Nat. Mus.); also a male, about 950 mm long, from Rio Tuyra, Panama, a female, about the same size, from Rio Culebra, Panama, tributary to the Pacific, and a saw, 560 mm long, from Rio Tilapa, Pacific Coast of Panama, these last three representing the closely allied *P. zephyreus* Gilbert and Starks 1895 (see discussion, p. 41, fn. 100).

Distinctive Characters. P. perotteti is easily distinguishable from *P. pectinatus* by its fewer sawteeth (normally 19 or fewer, rarely 20 on a side, 24–32 in *pectinatus*),[86] by its first dorsal originating considerably in advance of the origin of the pelvics (about on a line with the origin of the pelvics in *P. pectinatus*), by the much more deeply concave posterior margins of its dorsals, and by the fact that its caudal is not only relatively longer but has a well defined lower lobe (*cf.* Fig. 5 with 3). The position of its first dorsal relative to its pelvics and the presence of a lower caudal lobe similarly separate it from *P. pristis* (known only from the eastern Atlantic), which agrees with *P. pectinatus* in these respects but which has even fewer sawteeth than *P. perotteti* (see Key, p. 22).

Description. Proportional dimensions in per cent of total length. Male, 862 mm, from Para, Brazil (Harv. Mus. Comp. Zool., No. 302). Male, 1,376 mm, from Lake Nicaragua (U. S. Nat. Mus., No. 120468).

Breadth: between outer corners of pectorals 27.6, 31.4.

Snout length: in front of orbits 29.3, 24.8; in front of mouth 33.3, 28.5.

Orbits: horizontal diameter 1.7, 1.6; distance between 5.4, 5.2.

Spiracles: length 1.4, 1.5; distance between 4.5, 4.6.

Mouth: breadth 5.9, 5.7.

86. This is the character that has been invoked most often as an alternative, doubtless because many of the published records of the two species have been based on detached saws alone.

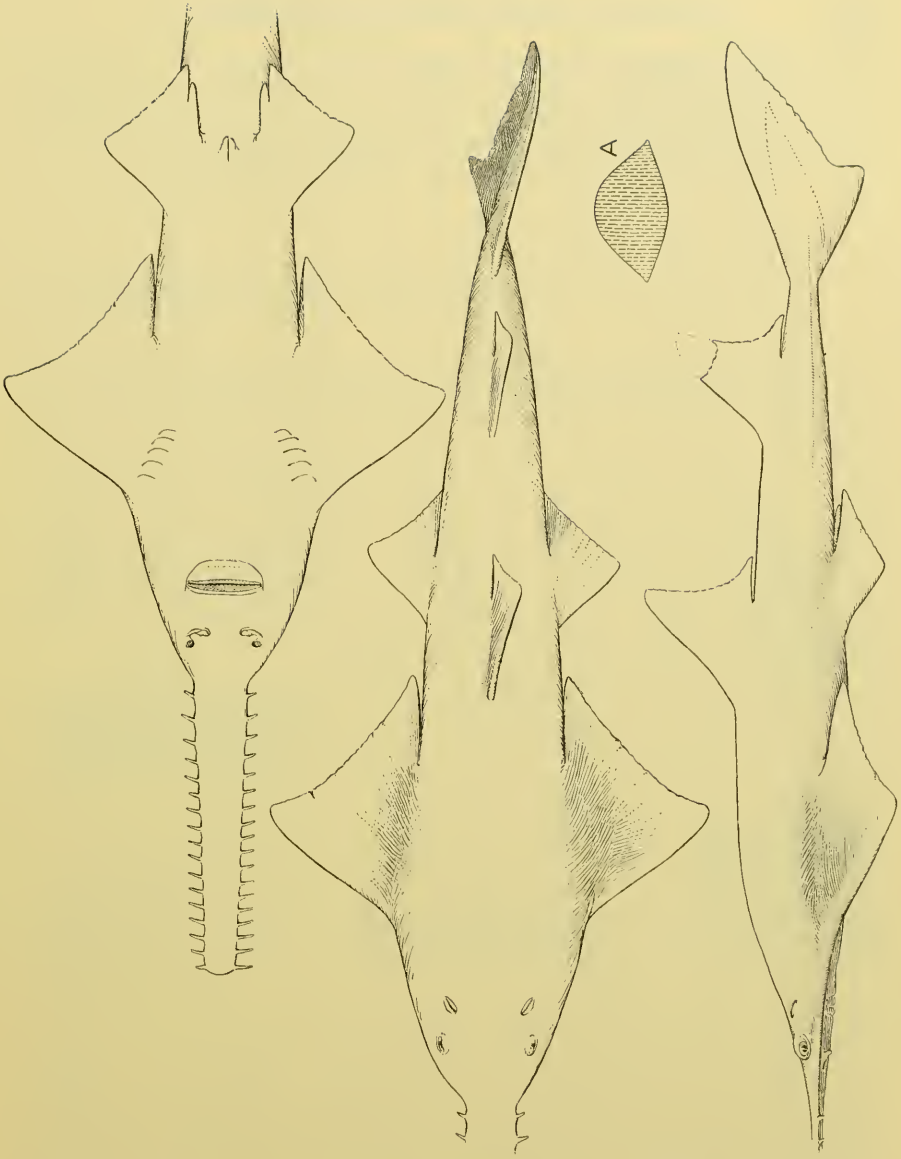

FIGURE 5. *Pristis perotteti*, juvenile male, about 1,376 mm long, from Lake Nicaragua (U. S. Nat. Mus., No. 120468). *A* Cross section of caudal peduncle close anterior to caudal fin, about 0.4×.

Nostrils: distance between inner ends 2.4, 2.3.
Gill openings: lengths, 1st 1.5, 1.5; 3rd 1.7, 1.7; 5th 1.0, 1.2; distance between inner ends, 1st 9.4, 9.7; 5th 7.1, 7.0.
First dorsal fin: vertical height 7.2, 7.9; length of base 7.5, 8.0.
Second dorsal fin: vertical height 7.1,—; length of base 6.0, 6.2.
Caudal fin: upper anterior margin 16.5, 17.6; lower anterior margin 8.3, 9.2.
Pelvics: anterior margin 6.2, 7.3.
Distance: from tip of snout to 1st dorsal 55.3, 51.7; to pelvics 60.8, 56.7; to center of cloaca 63.2, 60.5; from center of cloaca to lower caudal 21.2, 21.8.
Interspace between: 1st and 2nd dorsals 9.9, 11.6; 2nd dorsal and caudal 5.6, 5.7.

Trunk strongly flattened below, about 90 % as high as broad at origin of first dorsal, narrowing rather abruptly posterior to pectorals in small specimens but only gradually in larger ones, with a fleshy thickening or suppressed ridge low down along either side from a little posterior to rear tips of pelvics to base of caudal. Pectorals with nearly straight edges, directed outward much more abruptly from sides of head than in *P. pectinatus* (cf. Fig. 5 with 3); anterior edge nearly straight, distal edge about 1.1–1.2 times as long as anterior edge and weakly concave; outer corners narrowly rounded; posterior corners subangular. Extreme breadth across pectorals about as great as distance from mouth to axils of pelvics (thus considerably greater relatively than in *P. pectinatus*, p. 25). Caudal peduncle at rear end of base of second dorsal about 2.5 times or more as broad as thick, narrowing abruptly (as seen in dorsal view) to about 1.3 times as broad as thick at origin of caudal.

Dermal denticles more widely spaced in general over upper surface than in *P. pectinatus* (cf. Fig. 6 F with 4 G); their blades rather strongly oblique, ovoid, with more or less definite median ridge and marginal thickening toward base on either side; the bases more or less definitely four-cornered, evident through the skin in very young specimens but more concealed in larger. Denticles on saw rounded to oval, so closely crowded as to conceal the skin entirely; those along the margins largest; those on lower surface similar in form to those on upper surface, but more closely crowded.

Saw about as long as distance from front of eye to rear corner of pectoral and 1/5 of total length or a little more (20–22 %), thus somewhat shorter relatively than in *P. pectinatus*;[87] its width at base about 1/6 as great as its length on small specimens, increasing relatively to nearly 1/5 as wide as long on large; narrowing evenly forward to about 0.6 as wide at tip as at base on young and to 0.4–0.5 as wide at tip as at base on adults; its tip rounded; its margin not definitely narrowed between each two successive teeth.

Saw teeth 16–19, possibly 20 (17/18 on one of our specimens, 19/19 on others seen), sometimes with one more on one side than on the other,[88] spaced only a little more closely toward tip than toward base (considerably more closely toward tip in

87. For details as to saws and saw teeth in large specimens, see Baughman (Copeia, 1943: 44).
88. 16/17, 18/18, 18/18, 18/19, 19/19 reported in a series from Texas (Baughman, Copeia, 1943: 43).

P. pectinatus); about 4.5–5.0 times as long as broad; their longitudinal axes nearly transverse to main axis of saw; the basal eight or nine teeth on each side dipping downward, about on a plane with slope of upper surface of saw on their side, but the more distal teeth extending about horizontally; their average lengths about $^1/_3$ as great as width of saw, but varying considerably from tooth to tooth and without any regular gradation

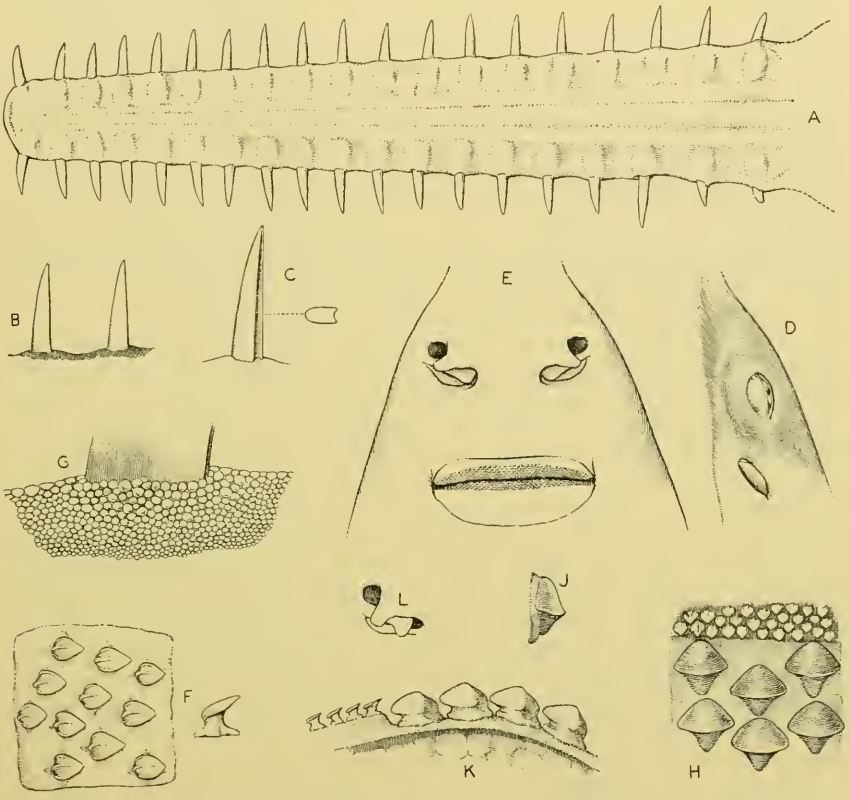

FIGURE 6. *Pristis perrotteti*. *A* Dried saw of specimen about 865 mm long (calculated length), from Lake Yzabel, Guatemala (U. S. Nat. Mus., No. 111423), about 0.4×. *B* Saw teeth from same, about 0.8×. *C* Oblique view of saw tooth from same, about 1.2×. *D* Eye and spiracle of juvenile male, about 1,376 mm long, from Lake Nicaragua (U. S. Nat. Mus., No. 120468), about 0.4×. *E* Lower surface of anterior part of head of same, about 0.4×. *F* Dermal denticles from below first dorsal fin of same, about 40×. *G* Dermal denticles along margin of saw of same, about 5×. *H* Dermal denticles on upper lip (smaller) and upper teeth (larger) from middle of jaw of same, about 9×. *J* Tooth of same in lateral view, about 8×. *K* Cross section of upper lip and anterior part of upper jaw of very young male from Para, Brazil (Harv. Mus. Comp. Zool., No. 302), to show dermal denticles (smaller) and teeth (larger) in side view, about 12×. *L* Nostril of same, about 0.8×.

between base of saw and its tip; length of longest tooth a little more than half as great as distance between nostrils; anterior margins of saw teeth sharp, but posterior margins flattened transversely even on very small specimens; teeth longitudinally channeled posteriorly on larger specimens; their anterior outlines weakly convex, their tips sharp on young specimens but more or less blunted on large; basal pair of teeth separated from apparent level of emergence of saw by a distance a little greater than length of orbit.

Head from origin of saw to level of first gill openings about $^1/_4$ of trunk from base of saw to origin of caudal; dorsal profile about as convex as in *P. pectinatus*, but lateral outlines narrowing more abruptly to base of saw (cf. Fig. 6 E with 4 F). Orbit about as long as spiracle; distance from anterior margins of orbits to base of saw, and length from mouth to base of saw, a little greater than width of mouth. Spiracles about 0.8 as long as nostril. Gill openings with anterior outlines strongly convex; distance between inner ends of fifth pair about equal to distance from mouth to base of saw. Nostrils with anterior margin expanded as a digitate lobe with rounded tip, extending rearward across nasal opening, the posterior margin following a continuous arc (bilobed in *P. pectinatus*, Fig. 4 F). Mouth transverse, nearly straight, with irregular folds at corners, its breadth about 2.4 times as great as distance between nostrils.

Teeth increasing in number of series from about $\frac{70}{70}$ on newborn specimens to about $\frac{80-90}{80-90}$ at a length of 1,300 to 1,400 mm, and perhaps more on larger individuals; dome-shaped anteriorly, with obtuse cutting edge, relatively somewhat larger than in *P. pectinatus*, and with bases extending farther posteriorly; rather loosely set in quincunx; the oral bands as in *P. pectinatus*, with about 12 rows in function simultaneously in each jaw.

The two dorsals of similar shape, with deeply concave posterior margins (much more so than in *P. pectinatus*); free lower margins less than half (about 40 %) as long as bases; apices narrowly rounded, their free rear tips subangular but blunted; anterior $^2/_3$ of base of first dorsal anterior to origin of pelvics, its origin opposite or a little anterior to level of rear corners of pectorals; base of second dorsal about 80 % as long as base of first dorsal. Interspace between first and second dorsals about 1.6 times as long as base of first dorsal. Interspace between second dorsal and caudal nearly or quite as long as base of second dorsal. Caudal subtriangular, with narrowly rounded corners, the lower expanded to form a low but definite lobe; upper margin nearly straight or weakly convex and nearly as long as distance from origin of second dorsal to origin of first dorsal (thus considerably longer relatively than in *P. pectinatus*); lower anterior margin weakly convex and about half as long as the upper; the caudal relatively narrower than in *P. pectinatus*, its vertical height at level of lower corner only about half as great as length of upper margin. Caudal axis only slightly raised. Pelvics about as long from origin to tip as interspace between first and second dorsals; their shapes as in *P. pectinatus*, except with distal margins weakly concave.

Color. Upper surface of trunk of salt-water specimens, when fresh-caught, either dark gray or golden brown, the base of the saw also golden brown in some cases. A

specimen from the fresh water of Lake Nicaragua is pictured[89] as being mouse gray on saw as well as over upper and lateral surfaces of anterior part of trunk; mouse gray shaded with reddish along midback posterior to first dorsal fin; reddish posterior to latter along lower part of sides; first dorsal pale yellow with reddish free rear corner; second dorsal, pelvics, caudal, and lower sides posterior to first dorsal dull brick red. But it is not clear whether the reddish tint was normal or was the result of suffusion with blood below the skin.

The preserved specimens that we have seen are dark gray above and grayish white below.

Size. The size at which *P. perotteti* first matures sexually is not known, but it has been suggested that it grows larger than *P. pectinatus*. The greatest lengths actually measured and recorded for *P. perotteti* are (in order of size) 17 feet 4 inches for one from the Ivory Coast, Equatorial West Africa;[90] 17 feet 4 inches, about 18 feet (15 ft. without saw), and 18 feet 7 inches for three others from Texas. But *P. perotteti*, like *P. microdon*, is said to reach a length of 20 feet, and apparently this is no exaggeration, for a saw of *P. perotteti* four feet long has been reported from Natal, Brazil.[91] And a length of about 21 feet 6 inches (6,500 mm) has been recorded[92] for its representative in the Indian Ocean (whether specifically identical or not, see p. 21).

Estimated weights of about 1,300 pounds for a Texas specimen 17 feet 4 inches long, 1,200 pounds for another of 18 feet 7 inches, as well as 1,320 pounds (600 kilo) for a large one (length not stated) from French Guiana,[93] suggest that adults of this species are heavier, at equal lengths, than *P. pectinatus* (p. 28), and they may grow as large in fresh water as in salt, for the weights of four recently caught in Lake Nicaragua ranged from 354 pounds to more than 700 pounds.[94]

Developmental Stages. Nothing is known of the course of development of this species to set it apart from *P. pectinatus* (p. 28).

Habits. Compared with *P. pectinatus*, *P. perotteti* is perhaps even more strictly confined to shallow water in the immediate vicinity of the shore and to estuarine localities, partially enclosed lagoons and similar situations. Perhaps the 15–20 foot contour line would enclose practically the entire stock of the species throughout its geographic range in both sides of the Atlantic, and it has long been known to be as much at home in pure fresh water as it is in brackish or salt. In fact, the type specimen of the species was taken from fresh water. Also, present indications are that it tends to run farther upstream in large rivers than *P. pectinatus* ordinarily does. Thus it has been taken something like 450 miles up from the sea in the Amazon River (p. 41) and has long been known in Lake Nicaragua. While it may not be strictly landlocked there, in a topographic sense, any more than it is up the Amazon, the fact that Sawfishes breed in the

89. Marden, Nat. geogr. Mag., *86*, 1944: 173 (colored photo).
90. Pellegrin, Poiss. Eaux douces Afr. Occ., 1923: 32.
91. By Starks, Leland Stanf. Univ. Pub., Univ. Ser., 1913: 6. A Sawfish taken in the Gulf of Paria, Trinidad, many years ago was reported as 22 feet long by 8 feet wide, but the account (Wilson, Charlesworth Mag. nat. Hist., N. S. *3*, 1839: 519) does not state how the measurements were taken, nor was the specimen identified as to species.
92. Annandale, Mem. Indian Mus., *2*, 1909: 6.
93. Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 89.
94. Marden, Nat. geogr. Mag., *86*, 1944: 184.

Lake[95] and are rather sluggish in habit (p. 20) makes it likely that most of the local inhabitants are permanent residents. In this connection, it would be interesting to know if any Sawfishes move back and forth indifferently between salt and fresh water in the tidal stretches at the mouths of the rivers they frequent or if individual specimens tend to remain constantly in one type of water or the other.

Throughout most of its American range, *P. perotteti* inhabits temperatures higher than 20° C (68° F). While it may be subject to temperatures as low as about 18° C (65° F) along the northeast coast of Texas during periods of severe winter weather, this is for short periods only. At the opposite extreme, it certainly is at home in water as warm as 28–30° C (82–86° F), or even warmer, along the shores of the Guianas and northern Brazil.

In the more strictly tropical part of its range, where it appears to be the most plentiful, as along the coast of French Guiana, small ones far outnumber the large (as is true also of *P. pectinatus* in its centers of abundance), which is evidence that while many young are produced their rate of survival is low. The fact that all specimens reported from the coast of Texas have been large, in contrast with the abundance of small ones farther south, also suggests that the production of young is confined chiefly to regions where the temperature of the water is at least as high as about 25–26° C (77–79° F) and that most of the large specimens taken to the northward in cooler water have spread from their tropical nursery, the journey perhaps occupying several years for any individual specimen, without return migration.

Nothing else is known of its way of life to differentiate it from its relative *P. pectinatus*. But it is of interest that a specimen reported from Texas as 15 feet long from front of head to tip of tail had lost its saw so long previously that the wound was entirely healed over,[96] evidence that a Sawfish can in some way obtain sufficient food without the use of its saw for stirring the bottom.

Numerical Abundance. No precise information is at hand as to the actual numbers of *P. perotteti* anywhere, but it has been characterized as common both along tropical West Africa and along French Guiana. The population inhabiting Lake Nicaragua is also so large that an angler reports catching four in one day. And in one summer seven large specimens were taken by one fisherman near Galveston, Texas.[97] However, most of the other published records of it have been based on single specimens, while it is described as not common in the Amazon, though well known there.[98]

Range. Both sides of the Atlantic; tropical West Africa in the east,[99] middle Brazil to northern Texas, and as a stray to southern Florida, in the west. It is represented by a closely allied form (or forms) along the Pacific Coast of Central America, off northern Australia, off Indo-China, among the East Indies, and in the tropical-

95. Females taken there dropped their young at the time of capture (Marden, Nat. geogr. Mag., *86*, 1944: 184).
96. Baughman, Copeia, 1943: 45.
97. By E. F. Reid (Baughman, Copeia, 1943: 43).
98. Woodland, Proc. zool. Soc. Lond., 1934: 33.
99. An illustration of *P. perotteti*, or at least of a Sawfish similar to it, is included by Costa in the Fauna Napoli (Pesci Cat. Sist., 3, 1854–1857: pls. 8, 9), but without mention of locality. There is no reason to suppose that *P. perotteti* ever strays as far north as the Mediterranean. A Sawfish is also reported under this same name from fresh water in South Africa (Barnard, Pict. Guide S. Afr. Fish., 1948: 22; not seen).

subtropical belt of the Indian Ocean, but its exact relationship to *P. perotteti* of the Atlantic remains to be determined (p. 21).[100]

Occurrence in the Western Atlantic. Knowledge of the presence of this particular species of Sawfish in the western side of the Atlantic is recent. In 1898, for example, leading ichthyologists wrote that it was "not authentically known, except from the rivers of Africa,"[101] and as recently as 1930 they wrote that it "probably does not occur in America."[102] Actually it had been reported long before from the coastal waters of tropical West Africa, from the Atlantic in general, and from the West Indies.[103] And a specimen in the Museum at Rio de Janeiro from Bahia de Batafogo, near Rio de Janeiro, was listed in 1903;[104] its specific identity was established positively a few years later by a photograph.[105] It is now known that *P. perotteti* is widely distributed in suitable locations along the coasts of America within the latitudinal limits stated above. Localities of record for it include: Santos, the vicinity of Rio de Janeiro, Bahia (São Salvador), Natal, and Marajó Island on the coast of Brazil, as well as the Amazon up to Parintins, some 450 miles inland from the sea; Dutch, British and French Guiana; Venezuela; the San Juan River, Colombia, tributary to the Gulf of Darien;[106] Lake Yzabel and vicinity, Guatemala; Lake Nicaragua; from unspecified localities in the Gulf of Mexico and West Indies and the Texas Coast from the Mexican border (Brownsville) to the Louisiana line (Port Arthur), where it is said to be more common than *P. pectinatus*. This last seems to mark the usual limit to its range in that direction, for it could hardly have been overlooked if it occurred in any numbers along the northern shore of the Gulf of Mexico. The only records of it in Florida waters are of a saw at Key West[107] and of a specimen taken at Salerno on the east coast.[108] Thus its latitudinal range is much less extensive than that of *P. pectinatus* on the American Coast, as is also the case in the opposite side of the Atlantic. And it has not been recorded for any locality on the Atlantic Coast north of Florida.

Synonyms and Atlantic References:[109]

Pristis perotteti[110] Müller and Henle, Plagiost., 1841: 108 (descr., meas., no. teeth, Senegal, fresh water), 192 (ref. to Valenciennes); Duméril, Arch. Mus. Hist. nat. Paris, *10*, 1861: 261 (listed, Senegal); Hist.

100. The Sawfish that has been variously recorded from the Pacific Coast of Central America as *P. zephyreus* Jordan and Starks 1895, as *P. microdon* Latham 1794, and as *P. perotteti* Müller and Henle 1841 appears separable from *P. perotteti* of tbe Atlantic only by the fact that it may have up to 23 sawteeth on a side (we have seen one with 20/22) as compared with a recorded maximum of only 19 or 20 for the Atlantic form. For references to it, see Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 253). For references to Sawfishes recorded from the western tropical Pacific-Indian Ocean region as *P. microdon* Latham 1794 and as P. *perotteti* Müller and Henle 1841, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 295).
101. Jordan and Evermann, Bull. U. S. nat. Mus., 47 (3), 1898: 2749.
102. Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23, footnote.
103. Günther, Cat. Fish. Brit. Mus., *8*, 1870: 436.
104. Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 80.
105. Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 173, pl. 11.
106. Specific identity of saws seen not altogether certain (Eigenmann, Mem. Carneg. Mus., 9, 1922: 25).
107. Saw with only 17 teeth on one side and 18 on the other, hence almost certainly this species (Baughman, Copeia, 1943: 46).
108. Reported to us by Stewart Springer.
109. For references to *P. zephyreus*, *P. microdon* and *P. perotteti* for the Indo-Pacific, see Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 253) and Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 295).
110. Sometimes spelled "*perrotteti*," or "*perroteti*."

Nat. Poiss., *1*, 1865: 474, pl. 9, fig. 2 (descr., ill. of saw, rivers of Senegal); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 436, in part (specimens from Atlant., W. Indies, but not from Chiapam, Guatemala, Zambesi and Bandjermassing); Steindachner, S. B. Akad. Wiss. Wien, *61* (1), 1870: 577 (nos., Senegal); Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 48 (size, nos., Senegambia); Steindachner, Denkschr. Akad. Wiss. Wien, *44*, 1882: 51 (listed, Senegal); Rochebrune, Faune Senegambie, *1*, Poiss., 1883–1885: 25 (same as Rochebrune, 1882); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 60 (descr.); Bull. U. S. nat. Mus., *47* (3), 1898: 2749 (known only from Afr. rivers); Evermann and Marsh, Bull. U. S. Fish Comm., *20* (1), 1902: 64 (Senegal, said to occur in W. Indies); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 80 (listed, Bahia de Batafogo, Brazil); Hargreaves, Fish. Brit. Guiana, 1904: 14 (habits, ill., Brit. Guiana, but specimen with 23 sawteeth probably *P. pectinatus*); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 173, 206, pl. 11 (diagn., size, refs., photo, Bahia de Batafogo, Brazil); Regan, Biol. Cent. Amer., Pisces, 1908: 183 (listed, Lake Nicaragua); Boulenger, Cat. Fr. Water Fish. Afr., *1*, 1909: 3 (listed for Gambia, but not refs. to Zambesi and Spire); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 469 (saws probably of this species, Bahia [São Salvador], Brazil, Gulf of Mexico and Surinam [Dutch Guiana]); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Starks, Leland Stanf. Univ. Pub., Univ. Ser., 1913: 6 (saw, Natal, Brazil); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Santos, Brazil); Fowler, Proc. Acad. nat. Sci. Philad., *71*, 1919: 129 (listed, Surinam [Dutch Guiana]); Metzelaar, Trop. Atlant. Visschen, 1919: 192 (listed both sides of Atlant.); Eigenmann, Mem. Carneg. Mus., *9*, 1922: 25 (saws, San Juan R. in the north, Colombia); Pellegrin, Poiss. Eaux douces Afr. Occ., 1923: 32 (color, size, Sassandra, Ivory Coast, W. Afr.); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 30 (diagn., same as Ribeiro, 1907); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 28 (cf. *P. pectinatus*); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23, footnote (Afr., prob. not Amer.); Gowanloch, Bull. La. Conserv. Dep., 21, 1932: 88 (not reported from Louisiana); Woodland, Proc. zool. Soc. Lond., 1934: 33 (Amazon R., near Parintins, Brazil); Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 89 (size, nos., French Guiana); Smith, H. W., Biol. Rev. (Cambridge), *11*, 1936: 64 (listed, fresh water); Bertin, Bull. Mus. Hist. nat. Paris, (2) *11*, 1939: 77, 78 (one of orig. specimens in Paris Mus., Senegal R.); Gunter, Amer. Midl. Nat., *26*, 1941: 196 (listed, Texas Coast); Baughman, Copeia, 1943: 43 (discuss., descr., photo of saw, cf. *P. pectinatus*, length, weight, Texas).

Pristis antiquorum Günther, Trans. zool. Soc. Lond., *6*, 1869: 397, in part (Atlant., but not Chiapam, Guatemala, and Pacif. ref.); Gill and Bransford, Proc. Acad. nat. Sci. Philad., 1877: 190 (saw, Lake Nicaragua); Meek, Field Mus. Publ. Zool., 7 (4), 1907: 104 (saws, Lake Nicaragua).

Pristis microdon Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 265, in part (descr., synonyms, and refs. for Atlant.); Fowler, Bull. Amer. Mus. nat. Hist., 70 (1), 1936: 95 (W. Afr. refs., descr., Brazil, Surinam [Dutch Guiana], Gulf of Mexico); Bull. Amer. Mus. nat. Hist., 70 (2), 1936: 1153 (in Key); Röhl, Fauna Descript. Venezuela, 1942: 366 (Venezuela; not seen); Marden, Nat. geogr. Mag., *86*, 1944: 184, 186, pl. 5 (color photo, weights, nos., Lake Nicaragua); Baughman, Copeia, 1947: 280 (17–18 sawteeth, Port Isabel, Texas); Schultz, Proc. U. S. nat. Mus., *99*, 1949: 21 (Maracaibo, Venezuela).

Probable Synonyms:

Pristis antiquorum Costa, Fauna Napol., Pesc. Cat. Sist., 3, 1854–1857: pls. 8, 9 (ills., no local.); Metzelaar, Trop. Atlant. Visschen, 1919: 192, in part (listed both sides Atlant.).

Pristis zephyreus Jordan and Starks, Proc. Calif. Acad. Sci., (2) *5*, 1895: 383 (descr., Rio Presidio, Gulf of California; for refs., see Beebe and Tee-Van [Zoologica N. Y., *26*, 1941: 253]).

Pristis pristis Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 30 (no. saw teeth, Brazil).

Pristis microdon Rey, Fauna Iberica, Peces, *1*, 1928: 501, 505 (ill., after Costa, 1854–1857); Miles, Peces Rio Magdalena, Ministr. Econ. Nac. Secc. Piscicult., 1947: 36, 37 (listed, estuary of Magdalena R., Colombia; not seen).

Not *Squalus pristis* Linnaeus, Syst. Nat., *1*, 1758: 235 (E. Atlant.).

Not *Pristis antiquorum* Latham, Trans. Linn. Soc. Lond., *2*, 1794: 277, pl. 26, fig. 1 (equals *Squalus pristis* Linnaeus 1758).

Probably not *Pristis microdon* Latham, Trans. Linn. Soc. Lond., *2*, 1794: 280, pl. 26, fig. 4 (no local., name commonly applied to Indian Ocean form; for refs., see Fowler [Bull. U. S. nat. Mus., 100 (13), 1941: 295]).

Suborder RHINOBATOIDEA

Guitarfishes

Characters. Trunk anterior to cloaca ranging from shark-like to disc-like in form. Snout without blade-like extension, its edges without teeth. Tail sector much stouter than in any other batoids excepting the Sawfishes (p. 18) and Torpedo Rays (p. 80), sharply marked off from body sector in disc-shaped species but not in those with a more shark-like form. Attachment of anterior expansions of pectoral fins to sides of head extending only a little past mouth in some, for various distances thence forward in others, and nearly to midline of snout in extreme cases. Two well developed dorsal fins, the first originating much closer to tips of pelvics than to tip of tail. Caudal fin well developed. Pelvics with outer margins convexly rounded and wholly separate from pectorals.

Eyes with an obscure fold of skin below. Nostrils entirely separate from mouth in most cases but connected with it by a broad shallow furrow[1] in some. Corners of mouth without voluminous furrows extending rearward.

Body and fins closely covered with small dermal denticles of various shapes, skin of upper and lower surfaces mostly concealed except for the interbranchial region, which is largely or wholly naked in some cases. Back more or less thorny along midbelt, on shoulders, around eyes and spiracles, and over rostral cartilage in some species. Tail without a serrate-edged spine.

Anterior margin of cranium with a single unbranched rostral projection[2] extending nearly or quite to tip of snout in most but falling considerably short of it in *Platyrhina* (p. 50), in which it is continued forward by soft ligamentous strands. In most species the separate antorbital cartilages do not take any part in supporting the anterior part of the head; in *Platyrhina* they extend forward beyond the orbital region but fall short of the anterior margin of the disc. Tips of branchial rays either cylindrical or somewhat expanded, less so than in the Torpedo Rays. Dorsal and caudal fins supported basally by short cartilaginous radials and distally by much more numerous fine horny rays (ceratotrichia) in double series. Pectoral and pelvic fins without horny rays, the cartilaginous radials extending outward to margins of pectorals, nearly to margins of pelvics. Pelvis transverse, either with or without a small anterior process at either end. Anterior and posterior surfaces of gill arches inward from gill filaments with a series of low, firm, widely-spaced knobs. No electric organs. Development ovoviviparous in most species, perhaps oviparous in a few (p. 47, fn. 11).[3]

Remarks. The rhinobatoids present nearly an unbroken series as regards shape of disc, length and shape of snout, degree of forward extension of pectorals, position of

1. This connection between nostril and mouth is described by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 289) as "deep" for *Platyrhina sinensis* (Bloch and Schneider) 1801; actually we found that it is shallow though broad in an excellently preserved specimen of that species from Japan.
2. Commonly termed "rostral cartilage," although it is continuous with the cranium.
3. For an account of the embryonic stages of *Rhynchobatos djiddensis*, see Setna and Sarangdhar [Rec. Indian Mus. (1948), *46* (1–4), 1949: 18–23, figs. 7–8, pl. 1, fig. 4].

dorsal fins on tail, conformation of anterior margin of nostril, and relationship of nostrils to mouth. Some recent authors, in fact, unite all of them in a single family, Rhinobatidae.[4] They can be grouped in two families, however, according to the shape of the caudal, including the degree of elevation of its axis, and according to the position of the dorsal fins relative to the pelvics.

Key to Families

1a. Caudal fin conspicuously bilobed, more or less lunate in form, both lobes sharp-pointed; axis of caudal fin bent upward to a moderate degree; posterior edges of pectorals considerably anterior to origin of pelvics; origin of first dorsal over or a little anterior to bases of pelvics. Rhynchobatidae,[5] p. 44.

1b. Caudal fin not bilobed, its axis bent upward only very little, if at all; posterior edges of pectorals extending rearward as far as origin of pelvics or farther; origin of first dorsal considerably posterior to posterior tips of pelvics. Rhinobatidae, p. 46.

Family RHYNCHOBATIDAE

Characters. General shape intermediate between shark-like and typical ray-like, only moderately flattened; tail sector not marked off from body sector. Snout not produced as a blade, ranging in different genera from short and broadly rounded to wedge-

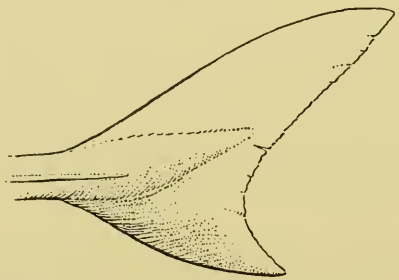

FIGURE 7. *Rhynchobatus djiddensis.* Caudal fin of male, 480 mm long, from Ceylon (Harv. Mus. Comp. Zool., No. 806), about 0.8×.

shaped and elongate; no teeth on margins of snout. Posterior corners of pectorals considerably anterior to origin of pelvics. Origin of first dorsal ranging from about over midpoint of bases of pelvics to a little anterior to origins of latter. Caudal fin definitely

4. Norman, Proc. zool. Soc. Lond., 1926: 941; Bertin, Bull. Inst. océanogr. Monaco, 775, 1939: 19.

5. Jordan (Class. Fish., Stanford Univ. Publ. Biol., *3* [2], 1923: 102) used the name Rhinidae for this family (derived from *Rhina* Bloch and Schneider 1801, see p. 45). But doing so is likely to lead to confusion, because *Rhina* has been used many times as the generic name of the squatinoid Sharks, though incorrectly so.

bilobed (Fig. 7) with deeply concave posterior margin; both upper and lower lobes sharp-tipped; caudal axis moderately raised, its termination near posterior margin of fin some distance below tip of upper lobe. Eyeballs with low rounded velum above pupil, the orbits outlined below and anteriorly by a deep furrow. Spiracles large, about as broad as long, close to eyes and either transverse or only slightly oblique, with inner ends directed rearward, their posterior margins with or without transverse folds. Rostral projection from cranium extending to tip of snout.

Genera. Two genera, *Rhynchobatus* and *Rhina*, are generally recognized.

Key to Genera.

1a. Snout narrow, pointed, its length in front of eyes nearly or quite as great as breadth of head at level of anterior margins of eyes; posterior margin of spiracles with two low vertical ridges; mouth only slightly undulate, with median projection of lower jaw fitting a corresponding depression of upper.

Rhynchobatus[6] Müller and Henle 1837
Tropical Indian Ocean, including Red Sea, south to Natal; tropical West Africa; Malay Peninsula; Philippines; East Asia north to Japan; Australia.[7]

1b. Snout broadly rounded, its length in front of eyes much less than breadth of head at eyes; posterior margin of spiracles without vertical ridges; mouth strongly undulate, with three forward projections of the lower jaw alternating with two rearward indentations of the upper.

Rhina Bloch and Schneider 1801.[8]
Tropical Indian Ocean in general, including the Red Sea and the Gulf of Oman; Malayan region; East Indies; Philippines; Australia; southeastern coasts of Asia northward to southern China and Japan.[9]

6. *Rhinobatis* Blainville 1825 (in Vieillot, Faune Franç., 1825: 47, 48) may have been an earlier name for the genus now known as *Rhynchobatus* (see p. 51, footnote), but we think it wiser to regard it as preoccupied by *Rhinobatos* Link 1790, since the use of names differing by only one letter for two different genera within the same suborder could only lead to confusion.

7. The type species (the only species known until recently) is *Rhynchobatus djiddensis* (Forskål) 1775 of the Indo-Pacific. A separate subspecific name, *australiae*, has been proposed by Whitley (Aust. Zool., *9*, 1939: 245; Fish. Aust., *1*, 1940: 173, fig. 197) for Australian specimens whose form is wider toward the root of the tail and whose color pattern differs from the typical *Rhynchobatus djiddensis*. But a small specimen of the latter from Ceylon, examined by us, agrees so closely in both these respects with Whitley's accounts and illustration of his *australiae* that it seems unnecessary to retain that name.

Three additional species have been described from tropical West Africa: *Rhynchobatus lübberti* Ehrenbaum (Fischerbote, *6*, 1914: 303), with which *R. atlanticus* Regan (Ann. Mag. nat. Hist., [8] *4*, 1915: 124) appears to be identical, *Rhynchobatus albomaculatus* (Norman) (Ann. Mag. nat. Hist., [10] *6*, 1930: 226), and *Rhynchobatus irvinei* (Norman) (Ann. Mag. nat. Hist., [10] *7*, 1931: 352). The last two were originally placed in *Rhinobatos* but are clearly referable to *Rhynchobatus* by their bilobed caudals.

8. The name *Rhina* was first used by Schaeffer (Epist., Stud. Ichthyol., 1760: 20) for the Shark genus properly known as *Squatina*, then by Klein (Neuer Schauplatz, *2*, 1776: 587), by Walbaum (P. Artedi Genera Pisc. Emend. Ichthyol., 1792: 58), and by some more recent authors. However, Schaeffer did not include any species in his genus *Rhina*, and the International Commission on Zoological Nomenclature has ruled (Opin. Rend., Smithson. Publ., No. 1938, 1910: 51; Smithson. miscell. Coll., *73* [3], 1925: 27) that neither Klein's names, nor Walbaum's revival of them, are to be taken into account. Consequently, *Rhina* as a generic name must date from Bloch and Schneider (Syst. Ichthyol., 1801: 352, pl. 72), who applied it to an Indian Ray with the specific name *R. ancylostomus*.

9. For list of localities recorded for *Rhina ancylostoma* Bloch and Schneider 1801, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 299).

Family RHINOBATIDAE

Characters.[10] Body sector of trunk ranging from moderately flattened, with wedge-shaped snout and tail sector not marked off from body, to strongly flattened and broadly rounded anteriorly in disc-like form, with tail sector more or less clearly marked off though moderately stout. Snout not produced as a blade, its edges without teeth. Anterior pectoral rays extending forward only a little past level of nostrils in some but to level of end of snout in others; posterior corners of pectorals extending rearward at least as far as origins of pelvics. Origin of first dorsal considerably posterior to rear tips of

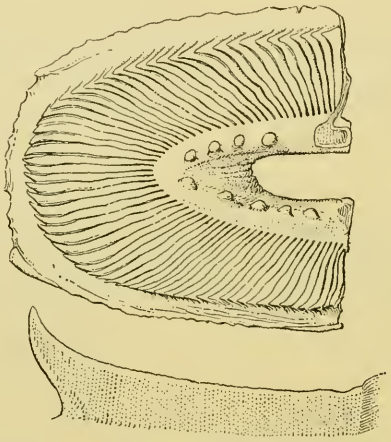

FIGURE 8. *Rhinobatos lentiginosus*, from off Useppa Island, Florida (Harv. Mus. Comp. Zool., No. 35856). Gill arch (above) and side view of gill fold (below), about 2.8×.

pelvics. Caudal without definite lower lobe, its posterior contour straight or convex, its corners rounded; caudal axis not raised, or only very slightly so (Fig. 14D; 18B). Eyes with or without rounded velum above pupil, the orbit outlined below and anteriorly by a deep groove in some species (as in the Rhynchobatidae) but only faintly so, if at all, in others. Spiracles immediately behind eyes, either transverse or slightly oblique, with inner ends directed rearward (as in Rhynchobatidae), their posterior margins with or without transverse folds. Rostral projection extending to tip of snout, or not. Anterior and posterior surfaces of gill arches, inward from gill filaments, each with a series of low, firm, widely-spaced knobs (Fig. 8).

Development is ovoviviparous in the great majority, but perhaps oviparous in

10. For account of the head skeleton and a comparison with other batoids, see Holmgren (Acta Zool. Stockh., *22*, 1941: 52, 64).

some.[11] In certain ovoviviparous species, all of the embryos in each uterus are enclosed at first in a single pillow-shaped capsule, from which they are later set free into the uterus, the walls of which are thickly set with villi.[12] It is not known whether multiple egg capsules of this sort occur in all ovoviviparous genera of the family.

Genera. Two genera referred to this family by us have been made the basis of a separate family by some authors,[13] partly because the rostral projection falls considerably short of the tip of the snout in one of them (*Platyrhina*), and probably in the other (*Zanobatus*[14]), whereas in all others it extends to the snout's extremity. In this respect, *Platyrhina* bears much the same relationship to the hard-nosed Guitarfishes, as exemplified by *Rhinobatos* or *Platyrhinoidis*, as do the soft-nosed Skates (*Psammobatis*, *Sympterygia*, *Breviraja*) to the hard-nosed Skates (*Raja*), with which they are united in a single family (Rajidae) by common consent. Therefore, we see no reason for their separation on this basis.[15]

Key to Genera

1a. Snout wedge-shaped, ranging from obtusely so to slenderly prolonged; tips of anterior rays of pectorals falling considerably short of tip of snout.

2a. Lobe-like expansion of anterior margin of nostrils far apart from each other and from upper lip.

3a. Lobe-like expansions of anterior margin of nostrils covering only a narrow belt midway of nasal opening.

4a. Posterior margin of spiracles with one or two well marked ridges or folds; nostrils more or less oblique; inward extension of lobe-like expansion of anterior margin of nostrils ending some distance outward from inner corner of nostril. *Rhinobatos* Link 1790, p. 50.

4b. Posterior margin of spiracles without folds; nostrils transverse; inward extension of lobe-like expansion of anterior margin of nostril crosses inner angle of nostril. *Aptychotrema* Norman 1926. Australia (two species).[16]

11. Müller (Denkschr. Akad. Wiss. Berl. [1840], 1842: 249, pl. 6, fig. 2; also separate, Ueber den glatten Hai, 1842: 62, pl. 6, fig. 2) found in the uterus of a *Zanobatus schoenleinii* an egg with a horny capsule, much resembling the eggs of the scyliorhinid Sharks; its shape suggested that embryonic development takes place after the eggs are laid, since it was provided with two coiled tendrils at one end.

12. This type of ovoviparity has been reported for the Australian *Aptychotrema banksii* (Müller and Henle) 1841, where each of the two capsules (one per uterus) contained 7–8 embryos (Haacke, Zool. Anz., *8*, 1885: 488, as *Rhinobatus vincentianus*, n. sp.); also for *Trygonorhina fasciata* (likewise Australian), in which each capsule contained two or three embryos. For illustrations of the egg capsule and of the villous uterine wall in the former, see McCulloch (Biol. Result. Fish. F. I. S. 'Endeavour', *5*, 1926: 158, figs. 1–4, as *Rhinobatus banksii*), and Whitley (Fish. Aust., *1*, 1940: 172, fig. 196, as *Aptychotrema vincentiana*). For an account of the embryonic stages of *Rhinobatos halavi* and *Rhynchobatos djiddensis*, see Melouk (Publ. Mar. biol. Sta., Ghardaqa, Fouad I Univ., 7, 1949).

13. Discobatidae (Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 258); Platyrhinidae (Fowler, Bull. U. S. nat. Mus., 100 [*13*], 1941: 289).

14. Norman (Proc. zool. Soc. Lond., 1926: 982) writes "as far as I am able to judge from a partial dissection of this very young example, the rostral cartilage does not reach the extremity of the snout."

15. In this we follow Norman's Synopsis (Proc. zool. Soc. Lond., 1926: 941).

16. The characters used by Norman (Proc. zool. Soc. Lond., 1926: 977) in separating the genus *Aptychotrema* from

3b. Lobe-like expansion of anterior margin of nostrils covering inner half of nasal opening almost entirely (Fig. 18C).

Zapteryx Jordan and Gilbert 1881, p. 74.[17]

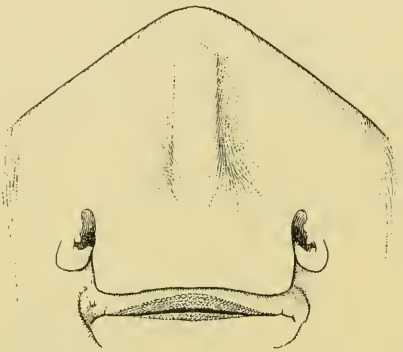

FIGURE 9. *Trygonorhina fasciata*, female, 254 mm long, from Port Jackson, New South Wales (Harv. Mus. Comp. Zool., No. 982). Ventral view of anterior part of head to show shape of nasal curtain, about 1.6×.

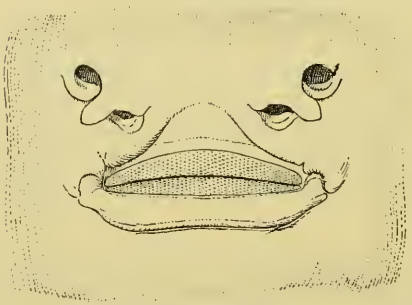

FIGURE 10. *Platyrhinoidis triseriata*, female, 452 mm long, from southern California (Harv. Mus. Comp. Zool., No. 36481). Nostrils and mouth, about 1×.

Rhinobatos are slight, but the genus has been accepted by both Whitley (Fish. Aust., *1*, 1940: 169) and Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 322); this course has the practical advantage of subtracting a few from the large number of closely related species of the genus *Rhinobatos*.

17. The nomenclatural history of the generic name *Zapteryx* is confused. The earliest named representative of the genus, *Rhinobatos* (*Syrrhina*) *brevirostris* Müller and Henle 1841, was placed by its authors in *Syrrhina*, their new subgenus of the old genus *Rhinobatos*. However, Müller and Henle failed to designate any one particular species as the type of *Syrrhina*. In 1881 Garman (Proc. U. S. nat. Mus., *3*, 1881: 521) revived *Syrrhina* for the Californian Ray that had been described the year before by Jordan and Gilbert (Proc. U. S. nat. Mus., *3*, 1880: 32) as *Platyrhina exasperata* but by Garman (Bull. Mus. comp. Zool. Harv., *6*, 1880: 169) as *Trigonorhina alveata*, which is

2b. Expansions of anterior margin of nostrils united to form a single broad quadrangular curtain, the free edge close to upper lip, with which it is united at isthmus (Fig. 9). *Trygonorhina*[18] Müller and Henle 1841.
Australia.

1b. Snout rounded; tips of anterior rays of pectorals reaching nearly or quite to tip of snout.

5a. Rostral cartilage extending nearly or quite to tip of snout.

6a. Dorsal surface of tail with three rows of prominent thorns; origin of first dorsal much nearer to origin of second dorsal than to rear tips of pelvics;

FIGURE 11. *Zanobatus schoenleinii*. Nostril with inner end to the left; after Norman.

lobe-like expansion of anterior margin of nostril almost entirely covering inner end of nasal aperture; posterior margin of nostril only slightly expanded (Fig. 10). *Platyrhinoidis* Garman 1881.
Coast of California from Point Conception southward.[19]

6b. Dorsal surface of tail with only one median row of large thorns; origin of first dorsal about midway between rear tips of pelvics and origin of second dorsal; lobe-like expansion of anterior margin of nostril leaving inner part of nasal opening exposed; posterior margin of nostril expanded as a broad rounded flap (Fig. 11). *Zanobatus* Garman 1913.
India and tropical West Africa.[20]

clearly congeneric with *Rhinobatos* (*Syrrhina*) *brevirostris* Müller and Henle 1841. But, since this revival of *Syrrhina* had been antedated by Jordan and Gilbert's (Proc. U. S. nat. Mus., 3, 1880: 53) proposal of the generic name *Zapteryx* for *exasperata*, we follow prevalent usage (Jordan and Evermann, Bull. U. S. nat. Mus., 47 [1], 1896: 64; Jordan, Genera Fish., *2*, 1919: 192; Norman, Proc. zool. Soc. Lond., 1926: 979; Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 252) in employing *Zapteryx* and in relegating *Syrrhina* to the synonymy of *Rhinobatos*. See also under generic synonyms of *Rhinobatos*, p. 50.

18. One species, *Trygonorhina fasciata* Müller and Henle 1841, with color varieties. These appear to be genetic rather than environmental, for specimens experimented upon showed only slight alterations in shade on white and on black backgrounds (Griffiths, Proc. Linn. Soc. N. S. W., *61*, 1936: 319). For an account of the skeleton of *Trygonorhina*, see Haswell (Proc. Linn. Soc. N. S. W., *9*, 1884: 107, pl. 2, figs. 1–5).

19. One species only, the *Platyrhina triseriata* of Jordan and Gilbert (Proc. U. S. nat. Mus., *3*, 1880: 36), for which Garman (Proc. U. S. nat. Mus., *3*, 1881: 522) proposed the genus *Platyrhinoidis*.

20. Illustrations of the adult of this genus (Müller and Henle, Plagiost., 1841: pl. 45; Steindachner, Denkschr. Akad. Wiss. Wien, *44*, 1882: pl. 7) seem to picture the rostral cartilage as extending nearly or quite to the tip of the snout. But it appeared not to reach the extremity of the snout in a very young one examined by Norman (Proc. zool. Soc. Lond., 1926: 982). The West African form, originally reported and pictured by Steindachner as *Platyrhina schoenleinii* Müller and Henle 1841, has been redescribed recently by Chabanaud (Bull. Soc. zool. Fr., *53*, 1928: 419) as a separate species, *Platyrhinoidis atlantica*.

5b. Rostral cartilage extending only a short distance beyond front of cranium and less than halfway to tip of snout.

Platyrhina[21] Müller and Henle 1841.
China and Japan.

Genus *Rhinobatos* Link 1790

Guitarfishes

Rhinobatos Link, Mag. Physik Naturg., Gotha, *6* (3), 1790: 32; diagnosis, but no species mentioned; evidently for *Raja rhinobatos* Linnaeus 1758, which is generally accepted as the type species.

Generic Synonyms:[22]

Rhinobatus Bloch and Schneider, Syst. Ichthyol., 1801: 353, and many subsequent authors; equivalent to *Rhinobatos* Link.[23]

Leiobatus Rafinesque, Caratt. Gen. Spec. Sicil., 1810: 16; type species, *L. panduratus* Rafinesque, Sicily; apparently equals *Squalus rhinobatos* Linnaeus 1758.[24]

Rhinobates Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1839: 193; equivalent to *Rhinobatos* Link 1790 and *Rhinobatus* Bloch and Schneider 1801.

Squatinoraja Nardo, Oss. Agg. Adr. Ittiol., 1824;[25] type species, *S. colonna* Nardo, designated by Jordan (Genera Fish., *1*, 1917: 116), equals *Rhinobatus columnae* Bonaparte 1835–1836.

Syrrhina (subgenus of *Rhinobatus*) Müller and Henle, Plagiost., 1841: 113, in part. For discussion, see p. 48, footnote 17.

Glaucostegus Bonaparte, Cat. Pesc. Europ., 1846: 14; type species, *Rhinobatus cemiculus* Geoffroy St.-Hilaire 1827; perhaps equals *Raja rhinobatos* Linnaeus 1758.[26]

Squatiniraja L. Agassiz, Nom. Zool., Index, 1846: 350; emended spelling for *Squatinoraja* Nardo 1824.

Acroteriobatis (subgenus) Giltay, Ann. Soc. zool. Belg., *59*, 1928: 26; type species, *Rhinobatus* (*Syrrhina*) *annulatus* Müller and Henle 1841, designated by Whitley (Aust. Zool., *9*, 1939: 244).

Scobatus (subgenus) Whitley, Aust. Zool., *9*, 1939: 244; type species, *Rhinobatus granulatus* Blainville 1816, designated by Whitley.

21. The name *Discobatus* was proposed by Garman (Proc. U. S. nat. Mus., *3*, 1881: 523) to replace *Platyrhina*, preoccupied by *Platyrhinus* Schellenberg 1798, for Coleoptera; and another substitute name, *Analithis*, had been proposed earlier by Gistel (Naturg. Tier., 1848: x). But this substitution is not required by the rules of Zoological Nomenclature as generally accepted at present. Two species are known, *Platyrhina sinensis* (Bloch and Schneider) 1801 and *P. limbomkenyi* Tang 1933 (Lingnan Sci., J., *12*, 1933: 561, pl. 42, figs. 1, 2). For excellent illustrations of *P. sinensis*, including skeletal characters, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 66).

22. The fossil genera *Aellopos* Münster 1836 (Neues Jb. Miner., 1836: 581), *Euryarthra* L. Agassiz 1843 (Poiss. Foss., *3*, 1843: 382) and *Spathobatis* Thiollière 1849 (Ann. Soc. Agric. Lyon, [2] *1*, 1849: 63) are included among the synonyms of *Rhinobatos* by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 305).

23. The generic name *Rhinobatus* had been employed previously by Klein (Neuer Schauplatz, *2*, 1776: 592) and by Walbaum (P. Artedi Genera Pisc. Emend. Ichthyol., *3*, 1792: 581). But the International Commission on Zoological Nomenclature has ruled (Opin. 21, Smithson. Publ., No. 1938, 1910: 51; Opin. 89, Smithson. misc. Coll., *73* [3], 1925: 27) that neither Klein's names nor their revival by Walbaum (1792) are to be taken into consideration.

24. *Leiobatus* had been proposed earlier by Klein (Neuer Schauplatz, *1*, 1775: 316) and republished by Walbaum (P. Artedi Genera Pisc. Emend. Ichthyol., 2, 1792: 581), its type being designated as *Raja oxyrincha* Linnaeus 1758 by Jordan (Genera Fish., *1*, 1917: 38).

25. *Squatinoraja* is credited to Nardo, as above, by L. Agassiz (Nom. Zool. Pisc., 1845: 61), by Schultze, Kükenthal, Heider, and Hesse (Nom. Anima. Gen. Subgen., 5 Lief. 23, 1937: 3260), and by Neave (Nom. Zool., *4*, 1940: 271). We have not been able to verify the citation.

26. While *R. cemiculus* St.-Hilaire (in Savigny, Zool. Egypte, *1* [1], 1817: 338, pl. 27, fig. 3) is retained as a distinct species by Norman (Proc. zool. Soc. Lond., 1926: 953) and by Rey (Fauna Iberica, Peces, *1*, 1928: 513, pl. 8, figs. 3, 4), it is referred to the synonymy of *R. rhinobatos* (Linnaeus) 1758 by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 305).

Platipornax (subgenus) Whitley, Aust. Zool., *9*, 1939: 244; type species, *Rhinobatus thouini* Müller and Henle 1841, designated by Whitley.

Doubtful Synonym:

Rhinobatis Blainville, in Vieillot, Faune Franç., 1825: 47, 48; type species, *Rhinobatis duhameli* Blainville.[27]

Generic Characters. Trunk strongly flattened anteriorly; anterior parts of disc more or less wedge-shaped. Width across pectorals considerably less than distance from tip of snout to cloaca. Body sector not sharply marked off from tail sector. Snout with rounded tip. Tail rounded above, flattened below, with a conspicuous longitudinal dermal fold along each side, extending from opposite or a little anterior to origin of first dorsal to origin of caudal. Pectorals with anterior rays extending only a little beyond nostrils; outer margins evenly convex, without definite corners; posterior corners broadly rounded. Dorsals about alike in size and shape, with free rear corners, their posterior margins straight or weakly concave. Origin of first dorsal much nearer to rear tips of pelvics than to origin of second dorsal. Interspace between dorsals at least twice as long as base of first dorsal. Caudal without distinct lower lobe. Pelvics widely separated one from the other posteriorly, with nearly straight margins and subangular corners. Posterior margin of spiracles with one or two well marked ridges or folds. The young of *Rhinobatos productus*, and perhaps of others, with a fringed membranous flap above on the tip of the snout that is lost with growth. Nostrils more or less oblique, wholly separate from mouth and well separated one from the other. Anterior margin of nostrils expanded as a narrow lobe across middle of nasal aperture, the lobe's inward extension widely separated from inner end of nostril, leaving inner part of nasal aperture exposed; posterior margin of nostrils also more or less expanded. Mouth transverse, nearly straight. Teeth numerous (up to 60–65 series, and perhaps more in some species), low, rounded, without cusp in females, but with low blunt cusp in adult males; those in each jaw in a pavement-like band. Dermal denticles minute, except for larger tubercles or thorns along median line of back, on shoulder regions, around eyes and spiracles, and on tip of snout in some species; in the young of some species, a row of thorns along each rostral ridge that is lost with subsequent growth.[28] Rostral projection of cranium extending to tip of snout, with two longitudinal ridges separated by a median furrow (visible externally). Claspers of mature males slender, strongly flattened dorsoventrally, their tips simple, without projecting spines or blade. Characters otherwise those of the family.

Size. Maximum length of largest species up to five or six feet.

27. We see no way of determining whether the name *Rhinobatis duhameli* Blainville 1825 was based on a *Rhinobatos* from the Mediterranean or on some member of the genus now known as *Rhynchobatus* from an unknown locality. Favoring the last of these alternatives is the fact that Duhamel's (Traité Pêches, *4* [2] Sect. 9, 1782: 292, pl. 15) illustrations, on which Blainville's account appears to have been based, show its caudal as having two lobes. On the other hand, Duhamel's characterization of it as being taken rather often in the Mediterranean, where *Rhinobatos* does occur but where *Rhynchobatus* does not, suggests that his illustration was of a *Rhinobatos* with the caudal incorrectly represented.

28. This is true of the eastern Atlantic *Rhinobatos cemiculus* as well as of the Californian-Mexican *Rhinobatos productus*, and perhaps of other species, the young stages of which are not known.

Developmental Stages. The Guitarfishes are ovoviviparous,[29] and it has long been known that the inner walls of the uterus in gravid females are thrown into a series of thin longitudinal folds.

Habits. They swim slowly near the bottom, or they lie half buried in the sand or mud. We read that in Australian waters "they can be easily approached and picked up by the tail."[30] When swimming, the muscular tail is used as the organ of propulsion, the pectoral fins to raise or lower the body or to turn and bank. Their food seems to consist mainly of small fishes or of crustaceans, shellfish, and other ground-living animals, which they crush with their small rounded teeth. Some of the Indian Guitarfishes are said to live in large schools and to do great damage to the pearl oyster beds of Ceylon and elsewhere.[31]

Relation to Man. In Peru, Guitarfishes are eaten extensively by the poorer people, mostly dried or salted, but they are regarded as mediocre in quality.[32] A few are also exposed for sale in tropical fish markets in other parts of the world, some are taken to rendering plants in California, while in India the fins of a few are prepared for export to China, where they are used for soup, as Shark fins are. They are not of interest to anglers and are entirely harmless to bathers.

Range. Tropical and warm temperate coastal waters of all oceans, running up into fresh water locally and even breeding there.[33] Eastern Atlantic northward to Portugal and the Mediterranean; southward along northwestern and tropical western Africa, at least to southern Benguela (recorded from Mossamedes, about Lat. 16° S).[34] Western Atlantic from North Carolina to Uruguay and northern Argentina.[35] Pacific Coast of the Americas from middle California (San Francisco) to Peru. Western Pacific from mid-China (Shanghai), Japan, and Korea to Queensland, Australia, in about Lat. 23–24° S; Philippines; Malayan region as a whole; south along West Australia to about Lat. 25° S (Sharks Bay); coasts of the Indian Ocean from Bay of Bengal, Arabian Sea, Gulf of Oman, Red Sea, and along the coast of Africa to Natal and to the Cape of Good Hope (Table Bay).

Species. Twenty-six species of *Rhinobatos* are recognized in the most recent synopsis of the genus[36] and four more have been described subsequently as new.[37] But the

29. See Southwell and Prashad (Rec. Indian Mus., *16*, 1919: pl. 18, figs. 1–4) for illustrations of early embryos prior to the fusion of the anterior parts of the pectorals with the head; see Ranzi (Publ. Staz. Zool. Napoli, *13*, 1934: 365) for a recent account, with photograph, of the uterine wall.
30. Whitley, Fish. Aust., *1*, 1940: 169.
31. Norman and Fraser, Giant Fishes, 1937: 59–60.
32. Fiedler, Jarvis, and Lobell, Pesca y Industr. Pesqu. Peru, Lima, 1943: 285; Hildebrand, Bull. U. S. nat. Mus., 189, 1946: 51.
33. Ogilby (Mem. Qd. Mus., 5, 1916: 95, ftn.) describes Guitarfishes in Australia as "freely entering and even permanently residing and breeding in fresh water."
34. We find no record of *Rhinobatos* from the West African Coast between about Lat. 16° S and Table Bay.
35. Reported to Lat. 40° S (Pozzi and Bordale, An. Soc. cient. argent., *120*, 1935: 153).
36. Norman, Proc. zool. Soc. Lond., 1926: 945.
37. *Rhinobatus banksii* McCulloch (Biol. Result. Fish. F. I. S. 'Endeavour', 5, 1926: 157), Australia; *Rhinobatos congolensis* Giltay (Ann. Soc. Zool. Belg., *59*, 1928: 21), tropical West Africa; *Rhinobatos petiti* Chabanaud (Bull. Mus. Hist. nat. Paris, [2] *1*, 1929: 365), Madagascar; and *Rhinobatos batillum* Whitley (Aust. Zool., *9*, 1939: 254), Australia. Two other recently named species, *R. albomaculatus* Norman (Ann. Mag. nat. Hist., [10] 6, 1930: 226) and *R. ir-*

characters, supposedly specific,[38] are so completely intergrading that the genus stands in urgent need of revision, which we are not in a position to attempt.

The Guitarfishes of the western side of the Atlantic fall in the group in which the snouts are relatively long, in which the anterior nasal flaps do not extend inward onto the internarial space, and in which there are two folds on the posterior margin of the spiracles. The great majority of western Atlantic specimens that have been described, or that we have seen, are rather evidently in one or the other of the two following categories.

A. Those with a cluster of prominent tubercles on the tip of the snout and with the rostral cartilage widening rather noticeably toward its tip. Specimens of this sort which have the upper surface of the trunk and tail densely freckled with a large number of small pale dots were the basis for the species *lentiginosus* Garman 1880, described from Florida. But the color pattern proves to be less dependable as a specific character than has been commonly assumed, for our Study Material includes both unmarked and sparsely spotted specimens from Texas that agree with typical *lentiginosus* in their morphological features.

B. Those without prominent tubercles on the snout and with the rostral cartilage widening less toward its tip; plain-colored or with indistinct dark markings, or with pale spots fewer and larger than in *Rhinobatos lentiginosus*. The western Atlantic representatives of this category, known from Panama and the West Indies southward to northern Argentina, have been described as three species, *R. percellens* (Walbaum) 1792, *R. horkelii* (Müller and Henle) 1841, and *R. stellio* (Jordan and Rutter) 1897. The first two are separable by the characters listed on pp. 56, 58. But there appears to be no distinction between *R. stellio* and *R. percellens* (p. 68),[39] and it seems doubtful whether a sharp line can be drawn between *R. percellens* and *R. lentiginosus*, for we have seen one young Texan specimen which had the spatulate rostral cartilage of *percellens* but which was plain-colored and had the rostral tubercles only faintly indicated (perhaps not yet developed). On the other hand, we have seen a Jamaican specimen which was typically *R. percellens* in coloration as well as in shape of rostral cartilage, but which had the tip of the snout armed with two rounded tubercles. Clarification of this puzzling situation must await further study of the Guitarfishes from the coasts of the Gulf of Mexico.

The group represented by the eastern Atlantic *R. rhinobatos* and its immediate allies, in which the anterior nasal flap extends inward across the inner margin of the nostril and so encroaches upon the internarial space (Fig. 12), has no known counterpart in the western Atlantic.

vinei Norman (Ann. Mag. nat. Hist., [10] 7, 1931: 352) from West Africa, with caudals pictured as bilobed, fal properly in *Rhinobatos* according to Poll (Résult. Sci. Exped. oceanogr. Belge Côt. Afr. Atlant. [1948–49], 1951: 91, 94).

38. Shape of snout and of rostral ridges; degree of inward extension of the flap-like expansions of the anterior margins of the nostrils; number (one or two) and prominence of the folds on the posterior margins of the spiracles.

39. The statement in the original account (Jordan and Rutter, Proc. Acad. nat. Sci. Philad., 49, 1897: 91) that the distance from the origin of the first dorsal to the origin of the second dorsal in *R. stellio* is equal to the distance from the axil of the pectoral to the origin of the first dorsal, was an evident slip, for re-examination of the original specimen (for which we have to thank the Natural History Museum of Stanford University) shows that axil of the pelvic was intended.

Finally, one more species, *R. spinosus* Günther 1870, must be mentioned because of the possibility that the one known specimen may have come from the Gulf of Mexico and hence may belong to the Ray fauna of the western Atlantic. It falls with *R. rasus* and with the young of *R. cemiculus* in the spininess of its rostral ridges. But we are not able to judge from the brief description (p. 73) how it is related to these species in other respects.

Provisional Key to North Atlantic, Western South Atlantic, and Tropical West African Species

1a. Anterior nasal flap extending across inner (anterior) margin of nostril as far as level of inner end of nostril (Fig. 12A); rostral ridges separated by a considerable interspace throughout their lengths. *rhinobatos* Linnaeus 1758. Portugal, Mediterranean, West Africa south at least to Lat. 16° S.[40]

1b. Anterior nasal flap extending but little, if at all, across inner margin of nostril (Fig. 12B–D); rostral ridges joined or close together anteriorly.

2a. Each rostral ridge with a more or less conspicuous row of small sharp thorns.

3a. Thorns on shoulders arranged one anterior to the other; distance from tip of snout to anterior margin of eye a little shorter than distance from posterior margin of eye to axil of pectoral (adult). *cemiculus* (St.-Hilaire) 1817 (young). Mediterranean to tropical West Africa.

3b. Thorns on shoulder arranged one beside the other; distance from tip of snout to anterior margin of eye equal to that from posterior margin of eye to axil of pectoral. *rasus* Garman 1908. Tropical West Africa.[41]

2b. Rostral ridges without sharp thorns.

4a. Rostral cartilage expanded toward tip, spatulate in form; tip of snout with a few enlarged tubercles, except perhaps on some small specimens (Fig. 14). *lentiginosus* Garman 1880, p. 60.

4b. Rostral cartilage not expanded toward tip; tip of snout without enlarged tubercles, except on some small specimens (Fig. 13A, C).

5a. Nostril only 1.0–1.2 times as long as distance between nostrils, and little more than half as long as breadth of mouth. *percellens* Walbaum 1792, p. 68.

5b. Nostril at least 1.4 times as long as distance between nostrils and about 3/4 as long as breadth of mouth.

40. Apparently including *albomaculatus* Norman 1930 and *irvinei* Norman 1931.

41. Norman (Proc. zool. Soc. Lond., 1926: 955) questions whether *rasus* is actually distinct from *cemiculus*, to which it certainly is closely allied, and Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 100) united the two. *R. spinosus* Günther 1870 would also fall under alternative 2a, if it is an Atlantic species (p. 73). But the only first-hand description of it that has appeared is not detailed enough for us to be able to include it in this Key.

6a. Distance from tip of snout to level of fronts of orbits about equal to distance from rear margins of orbits to axils of pectorals. *congolensis* Giltay 1928.[42]
Belgian Congo Coast.

6b. Distance from tip of snout to level of fronts of orbits considerably less than distance from rear margins of orbits to axils of pectorals.

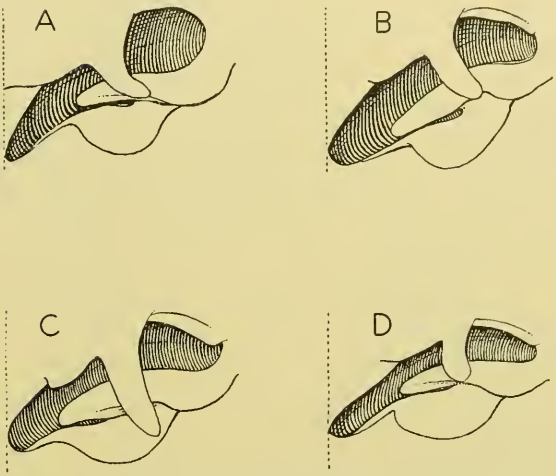

FIGURE 12. Left-hand nostrils, A *Rhinobatos rhinobatos*, male, about 720 mm long, from Mediterranean (Acad. Nat. Sci. Philad.). B *R. lentiginosus*. C *R. percellens*. D *R. horkelii*.

7a. A cluster of 3–4 enlarged tubercles on each shoulder, with one over outer end of pectoral girdle; snout in front of mouth more than three times as long as breadth of mouth; outer fold on posterior margin of spiracle conspicuously larger than inner fold. *horkelii* Müller and Henle 1841, p. 56.

7b. Only two tubercles on each shoulder and none over outer end of pectoral girdle; snout in front of mouth considerably less than three times as long as breadth of mouth; outer fold on posterior margin of spiracle not conspicuously larger than inner fold.
cemiculus (St.-Hilaire) 1817 (adult).
Mediterranean to tropical West Africa.

42. *R. congolensis* may prove to be identical with *R. cemiculus*.

Rhinobatos horkelii (Müller and Henle) 1841

Brazilian Guitarfish

Figures 12D, 13A, B

Study Material. Four specimens, male and female, 525 to 840 mm long, from Rio de Janeiro, Brazil, in Harvard Museum of Comparative Zoology.

Distinctive Characters. R. horkelii closely resembles both *R. lentiginosus* and *R. percellens* in general form. However, its nostrils are longer relatively than in either of these; its crown is flat transversely or even slightly convex (definitely, if only slightly, concave in *R. lentiginosus* and in *R. percellens*); its tubercles in the median row are larger, more thorn-like, and more numerous; the origin of its first dorsal is posterior to the tips of its pelvics by a distance about equal to the base of the first dorsal (by a distance about equal to the extreme length of the first dorsal from origin to rear corner in the others); and its teeth are fewer in number than in the other two species. Its plain coloration is a field mark which sets it off from most specimens of *R. lentiginosus* and *R. percellens*. Its narrower rostral projection distinguishes it further from *R. lentiginosus*. And the anterior nasal flap differs in detail in these three species (Fig. 12).

Description. Proportional dimensions in per cent of total length. Male, 705 mm, and female, 790 mm, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 544).

Disc: extreme breadth 33.0, 34.7; length 38.6, 40.3.

Snout length: in front of orbits 15.2, 16.8; in front of mouth 17.7, 19.2.

Orbits: horizontal diameter 2.8, 2.7; distance between 3.9, 4.2.

Spiracles: length 2.1, 1.9; distance between 5.1, 5.5.

Mouth: breadth 5.4, 5.8.

Nostrils: length 3.5, 3.7; distance between inner ends 2.4, 2.5.

Gill openings: lengths, 1st 1.8, 1.6; 3rd 1.8, 1.8; 5th 1.1, 1.5; distance between inner ends, 1st 12.2, 13.0; 5th 8.9, 9.6.

First dorsal fin: vertical height 6.4, 7.2; length of base 5.1, 4.8.

Second dorsal fin: vertical height 6.0, 6.8; length of base 5.7, 5.6.

Caudal fin: upper anterior margin 15.0, 15.6.

Pelvics: origin to tip 14.5, 16.0.

Distance: from tip of snout to center of cloaca 40.8, 42.7; from center of cloaca to tip of tail 59.2, 57.3; from tip of snout to 1st dorsal 56.6, 58.8.

Interspace between: 1st and 2nd dorsals 10.5, 10.2; 2nd dorsal and caudal 6.3, 5.6.

Disc about $^{5}/_{6}$ as broad as long to posterior limits of pectorals; wedge-shaped anteriorly but with well rounded tip, its angle in front of orbits about 50–60°; antero-lateral contours slightly concave anterior to level of eyes, posterior margins evenly and moderately convex, posterior corners well rounded. Tail from center of cloaca 1.3–1.4 times as long as distance from snout to cloaca, nearly flat below, moderately rounded above, tapering evenly rearward, its breadth opposite axils of pelvics about twice as

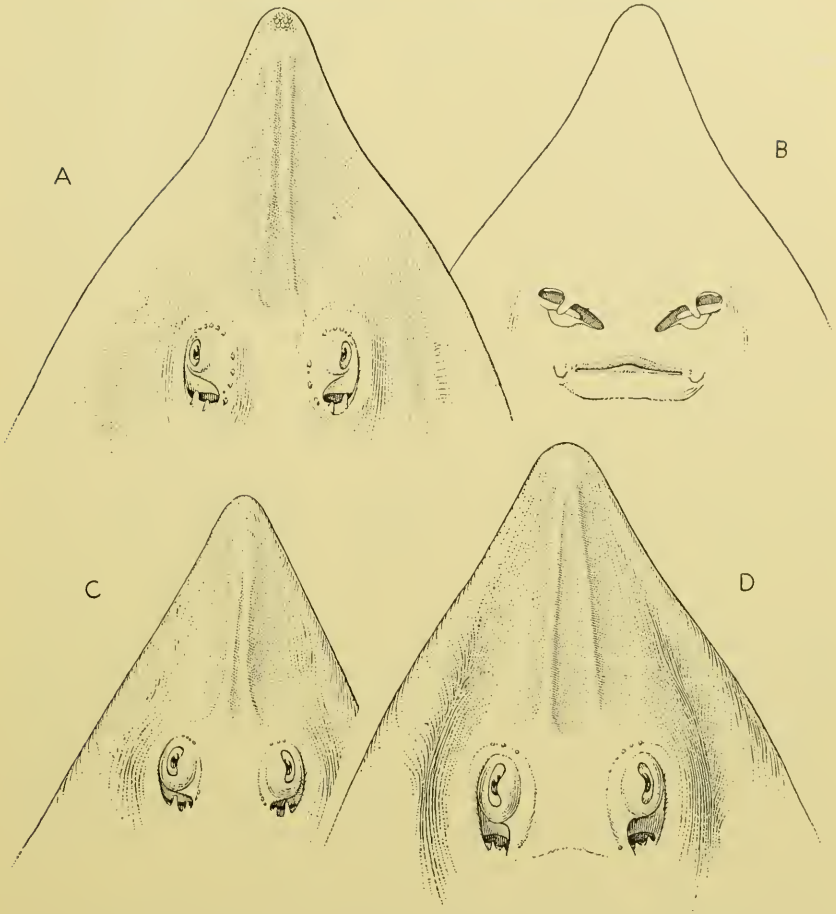

FIGURE 13. *Rhinobatos horkelii*, male, 700 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 544). *A* Anterior part of head in dorsal view. *B* Ventral view of same. *C* Anterior part of head, dorsal view, of *R. percellens*, 557 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 435). *D* Anterior part of head of *R. rhinobatos*, from Italy (Acad. Nat. Sci. Philad.). All about 0.6×.

great as distance between spiracles; its lateral dermal folds originating about opposite or a little in advance of tips of pelvics and extending as far as lower origin of caudal, their width opposite interspace between dorsals (where widest) about $^1/_3$ as great as horizontal length of eye.

Dermal denticles minute, close-set, mostly spear-shaped and rounded anteriorly over upper surface in general from nuchal region rearward, but some more ovate with skin more or less exposed between them; those on crown narrower, fluted anteriorly; those on snout flat, roundish to ovate; those on lower surface rounded to tetragonal with blunted corners, varying in size, so close-spaced that the skin is nearly or wholly concealed. Midline of back rearward from nuchal region with a more or less regular row of tubercles, each with sloping median ridge, more prominent than those of *R. lentiginosus* and of *R. percellens* but irregularly interspersed with smaller; up to about 70 tubercles to first dorsal fin, about 8 to 12 between dorsals, and a few smaller ones close beyond rear end of second dorsal; each shoulder with 2–4 somewhat lower tubercles, with one over each outer end of pectoral girdle[43] on small as well as on large specimens; 4–7 larger and smaller and more conical ones close in front of orbit; 2–6 along inner margin of orbit, with one or two close to inner end of spiracle; tip of snout with 2–4 small rounded tubercles on small and on some medium-sized specimens but without tubercles on large ones.

Snout in front of orbits about 3.7 times as long as distance between orbits in young, about 4.0 times as long in large specimens of both sexes; its length in front of mouth about 3.0 times as great as width of mouth in young and about 3.3 times as great in larger specimens. Horizontal diameter of eye about half as long as distance between spiracles. Length of orbit plus spiracle about $^2/_3$–$^3/_4$ as great as distance between spiracles. Spiracles about $^3/_4$ as long as orbit, nearly transverse, posterior margin with two well marked folds or ridges, the outer the longer. First to fourth gill openings of about equal lengths, about half as long as nostril, the fifth a little shorter; distance between inner ends of fifth gill openings about 1.6 times as great as breadth of mouth. Nostrils moderately oblique, their length about 1.5 times as great as distance between them and about $^2/_3$ (63–66 %) as great as width of mouth; anterior margin expanded near the middle as a narrow lobe with rounded tip, curving outwardly and across nasal aperture and extending inward a short distance as a narrow fold that ends abruptly without encroaching on the internarial space; posterior (outer) margin of nostril expanded as three confluent flaps, two of them shorter and directed rearward, the third longer, digitate, originating about opposite anterior nasal flap and extending along nasal aperture about 40 % of the distance from its own origin toward inner corner of nostril.

Teeth $\frac{56-68}{62-74}$ in specimens 515–790 mm long, those of immature specimens close-set in quincunx; low, oval, the longer axis transverse, with indistinct transverse cutting edge; the base extending a little rearward much as in *R. lentiginosus*; those of mature males not seen.

First and second dorsals about equal in size, triangular, with abruptly rounded corners, their anterior margins straight or slightly convex, the posterior margins straight or slightly concave and approximately vertical, the free rear corner about $^1/_2$–$^3/_5$ as long

43. The type specimen had no tubercles over the outer ends of the pectoral girdle (Müller and Henle, Plagiost., 1841: 122), but they are present on all that we have seen.

as the base; origin of first dorsal posterior to tips of pelvics by a distance about equal to base of first dorsal or a little greater. Interspace between dorsals about twice as long as base of first dorsal. Interspace between rear end of base of second dorsal and upper origin of caudal about 1.0–1.2 times as long as base of second dorsal. Upper origin of caudal a little anterior to lower; upper margin weakly convex, about 1–1.5 times as long as interspace between dorsals; lower posterior contour well rounded, without distinct lower lobe; height of caudal above extremity of axis about as great as its depth below latter. Caudal axis only slightly raised (perhaps horizontal in some cases). Pelvics with anterior, inner and distal margins nearly straight, the outer corners broadly rounded, forming an angle of about 130°, the posterior corners narrowly rounded; extreme length of pelvics, origin to rear tip, about 1.6–1.8 times as great as distance from origin of pelvic to axil; their axils separated by a distance about 1.2–1.4 times as great as breadth of mouth.

Rostral cartilage nearly uniform in breadth throughout most of its length, widening in somewhat rounded outline toward tip, its maximum breadth there about 1.0–1.1 times as great as distance between inner ends of nostrils; its ridges close together and approximated at tip. Anterior rays of pectorals extending anterior to nasal capsules of cranium by a distance about 1.3–1.4 times as great as distance between nostrils.

Color. Upper surface uniform olive gray or chocolate brown, without pale or dark markings. Lower surface either a pale shade of the same hue as upper surface or as dark as upper surface;[44] snout with an oval sooty patch in some but only faintly washed with sooty in others.[45]

Relation to Extralimital Species. R. horkelii closely resembles *R. cemiculus* St.-Hilaire 1827 of the eastern Atlantic but appears to be separable from it by a longer snout and by the facts that the outer of the two folds on the posterior margin of its spiracle is conspicuously larger than the inner and that there are 3–4 tubercles on each of its shoulders (only two in *R. cemiculus*); furthermore, *horkelii* seems to be separable from *cemiculus* by the presence of a larger number of tubercles (about 70; see p. 49) along the midline of its back from nuchal region to first dorsal fin (only about 18–20 in *R. cemiculus*).[46]

R. horkelii is closely allied to *R. productus* of the Pacific Coast of Mexico and California, but when half-grown or larger it is separable from *R. productus* by the fact that the origin of its first dorsal fin is posterior to the tips of the pelvics by a distance about as great as that between the eyes or about as long as the base of the first dorsal (less than half as long as distance between eyes and only a little more than half as long as base of first dorsal in *R. productus*). The tubercles around the eyes and on the shoulders are more prominent in *R. horkelii* than in *R. productus*, those in the median dorsal row larger and more regularly arranged, especially in the interspace between the two dorsal

44. Specimens with pale undersurfaces were classed as a color variety in the original account of the species. Those that we have seen are paler below than above, but evidently they have lost most of their original color.
45. Our Study Material includes examples of each of these color phases.
46. The original illustration of *R. cemiculus* (St.-Hilaire, in Savigny, Zool. Egypte, *1* [1], 1827: pl. 27, fig. 3), modified by Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 100, fig. 37), shows only 18.

fins. And the nostrils are up to 1.5 times as long as the distance between them in some *R. horkelii* but not more than 1.3 times that in *R. productus*. It is not possible to make a comparison of the younger stages for lack of information about *R. horkelii*.

Size. Evidently this is the largest Guitarfish of the western Atlantic, for the claspers of a male 700 mm long still fall a little short of the tips of the pelvics. A female in our Study Material, 840 mm long, is the largest yet reported; the size at maturity is not known.

Developmental Stages. The embryos have not been seen, nor have we seen newborn young.

Habits. Nothing is known.

Range. Coast of Brazil, perhaps north to the Lesser Antilles. Although *R. horkelii* has been known to science for more than half a century, and although it is easily distinguishable from both of the other species of its genus that occur in the western Atlantic, all that is known about its geographic distribution is that a few were collected many years ago[47] at Rio de Janeiro and at Bahia, Brazil, and that one small specimen has been reported more recently from the Lesser Antilles (St. Eustatius?), but without sufficient information to establish its specific identity with certainty.

Synonyms and References:

Rhinobatus (*Rhinobatus*) *horkelii* Müller and Henle, Plagiost., 1841: 122, pl. 41 (descr., meas., color, ill., Brazil), 192 (color); Duméril, Hist. Nat. Poiss., *1*, 1865: 499 (descr., Bahia, Brazil).

Rhinobatus horkelii[48] Castelnau, Anim. Nuov. Rares Amer. Sud., Poiss., 1855: 100 (listed, Bahia, Brazil); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 444 (cf. *R. undulatus*); Garman, Proc. U. S. nat. Mus., 3, 1880: 518 (descr., color, Brazil); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 175, 207 (diagn., refs., Rio de Janeiro and Bahia, Brazil); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 280 (descr., cf. *R. percellens*, Rio de Janeiro); Metzelaar, Trop. Atlant. Visschen, 1919: 7 (color, W. Indies, St. Eustatius?); Ribeiro, Arch. Mus. nac. Rio de J., Fauna Brasil., Peixes, *2* (1) Fasc. 1, 1923: 31 (diagn., color, cf. *R. percellens*, Bahia, Brazil); Norman, Proc. Zool. Soc. Lond., 1926: 947 (in Key), 976 (descr., ill. head, Brazil); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 1, 1930: 23 (listed, Brazil to St. Eustatius, Windward Is.).

Rhinobatos lentiginosus (Garman) 1880

Spotted Guitarfish

Figures 8, 12 B, 14, 15

Study Material. Thirteen specimens, male and female, 350–577 mm long, from Progresso, Yucatán; Freeport, Texas; Pensacola, Key West, Palmetto Key, Pine Island Sound, Captiva Pass, and New Smyrna Beach, Florida; Charleston, South Carolina; and Cape Lookout, North Carolina; embryo 180 mm long, nearly ready for birth, from Charleston, South Carolina; also 13 specimens from Texas which apparently represent a color variant of this species; all in the collections of Harvard Museum of Comparative Zoology, Museum of Zoology at University of Michigan, and U. S. National Museum.

47. Those in our Study Material were collected between 1859 and 1872.

48. Also spelled *horkeli*.

FIGURE 14. *Rhinobatos lentiginosus*. *A* Female, 577 mm long, from Captiva Pass, Florida (Harv. Mus. Comp. Zool., No. 35857). *B* Upper surface of tip of snout of same to show tubercles, about 1.6×. *C* Male, 508 mm long, from Captiva Pass (Harv. Mus. Comp. Zool., No. 35857). *D* Side view of tail of same. *E* Lower surface of tip of snout of female 518 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36408).

Distinctive Characters. The peculiar shape of the disc and the long wedge-shaped snout, combined with the stout muscular tail and its two well developed dorsal fins, mark *Rhinobatos lentiginosus* off from all other batoids of the western Atlantic except its genus mates *R. percellens* and *R. horkelii* (see discussion, p. 53). The spatulate rostral cartilage of *R. lentiginosus*, its relatively shorter nostrils, and the fact that the tubercles along the midline of its back are smaller and less thorn-like in shape, set it apart from *R. horkelii*; so too, the pale-spotted color pattern of specimens that are marked in that way. Its tubercle-tipped snout and more broadly spatulate rostral cartilage differentiate it from *R. percellens*, while the color pattern differs in detail between such specimens of *lentiginosus* and *percellens* as are marked with pale spots (p. 68).

Description. Proportional dimensions in per cent of total length. Male, 508 mm, from Captiva Pass, Florida (Harv. Mus. Comp. Zool., No. 35857). Female, 577 mm, from Pine Island, Florida (Harv. Mus. Comp. Zool., No. 35856).

Disc: extreme breadth 29.9, 33.0; length 39.0, 41.7.
Snout length: in front of orbits 14.2, 14.0; in front of mouth 17.3, 17.3.
Orbits: horizontal diameter 3.5, 3.4; distance between 3.1, 2.9.
Spiracles: length 2.0, 2.0; distance between 5.1, 5.2.
Mouth: breadth 6.4, 6.2.
Nostrils: length 3.8, 3.6; distance between inner ends 3.3, 3.1.
Gill openings: lengths, 1st 1.3, 1.2; 3rd 1.4, 1.5; 5th 1.0, 1.0; distance between inner ends, 1st 12.4, 12.7; 5th 8.2, 9.0.
First dorsal fin: vertical height 6.3, 6.4; length of base 4.8, 4.5.
Second dorsal fin: vertical height 6.6, 6.5; length of base 5.3, 4.9.
Caudal fin: upper anterior margin 14.9, 13.5.
Pelvics: origin to tip 16.5, 15.2.
Distance: from tip of snout to center of cloaca 41.3, 45.2; from center of cloaca to tip of tail 58.7, 54.8; from tip of snout to 1st dorsal 59.3, 60.7.
Interspace between: 1st and 2nd dorsals 11.2, 10.0; 2nd dorsal and caudal 5.9, 5.9.

Disc about $^{3}/_{4}$–$^{4}/_{5}$ as broad as long to posterior limits of pectorals; wedge-shaped anteriorly but with well rounded tip, its angle in front of orbits about 50°; posterior corners well rounded; anterolateral contours nearly straight in young specimens but slightly concave anterior to the level of eyes in large; posterior margins evenly and moderately convex; posterior corners of pectorals overlapping pelvics by a distance about as long as that between nostrils. Tail from center of cloaca 1.2–1.4 times as long as distance from snout to cloaca, nearly flat below, moderately rounded above, tapering evenly rearward, its breadth opposite axils of pelvics about twice as great as distance between spiracles; its lateral dermal folds originating opposite tips of pelvics and extending to lower origin of caudal, their width opposite interspace between dorsals (where widest) about $^{1}/_{3}$ as great as horizontal length of eye.

Dermal denticles on upper surface minute and close-set, but skin exposed between them; low, flattish or slightly domed; those along midzone of back ovate posteriorly,

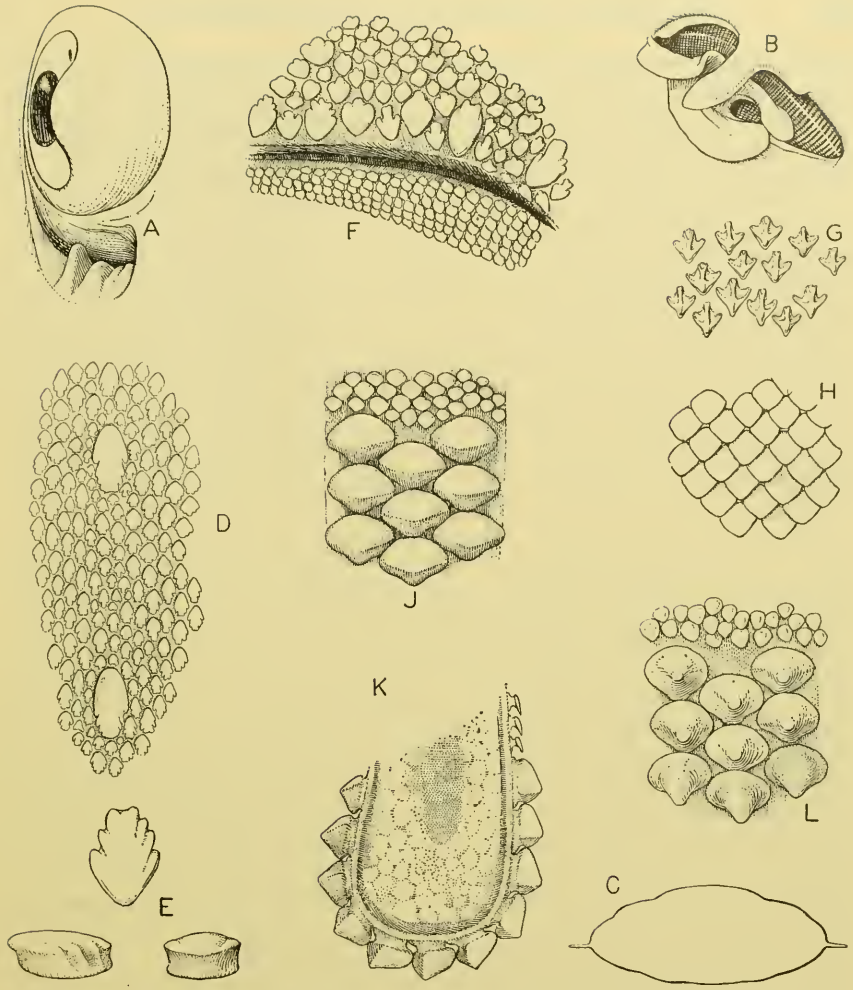

FIGURE 15. *Rhinobatos lentiginosus. A* Eye and spiracle of female, about 2×. *B* Nostril of male, about 2×. *C* Cross section of posterior part of trunk of female at level of first dorsal fin, about 1.0×. *D* Dermal denticles along midline of back of female between nuchal region and pectoral girdle, anterior ends uppermost, about 10×. *E* Dermal denticle of female from beside mid-dorsal line, in dorsal, anterior, and lateral views, about 38×. *F* Dermal denticles of female from along upper margin of orbit, about 10×. *G* Denticles on side of snout of male, about 24×. *H* Denticles on lower side of pectoral fin of male, about 24×. *J* Denticles on upper lip (smaller) and teeth (larger) from middle of jaw of female, about 14×. *K* Cross section of upper jaw of same to show denticles on upper lip (smaller) and teeth of successive rows (larger), about 14×. *L* Denticles on upper lip (smaller) and teeth (larger) of mature male, about 14×. *A*, *C–F*, *J*, *K* from female, 577 mm long, from off Useppa Island, Florida (Harv. Mus. Comp. Zool., No. 35856). *B*, *G*, *H*, *L* from mature male, 508 mm long, from Captiva Pass, Florida (Harv. Mus. Comp. Zool., No. 35857).

of various sizes, but irregularly fluted or arrowhead-shaped anteriorly; those on either side of rostral ridge spear-shaped and sharp-pointed with concave margins; those along sides of tail generally ovate and more or less pointed; those along outer margins of pectorals and of snout, around orbits, and along margins of spiracles, smaller, more rounded, and more closely crowded. Usually 33–37 larger tubercles along midline of back, from nuchal region to first dorsal; similar to smaller scales in shape, or more pointed posteriorly, but varying widely in prominence (apparently irrespective of age or sex); thorn-like on some but so slightly conspicuous on others as to be detected only by touch or by examination with a lens; eight or nine smaller tubercles in interspace between dorsal fins on some specimens; some with one or two small tubercles on scapular region on one side or on both; anterior and posterior sectors of orbital ridge with enlarged flattish denticles in some cases. Tip of snout of typical specimens conspicuously armed with blunt conical tubercles or thorns, varying in number from 2–7 or perhaps even more in later stages of growth; see discussion (p. 53). Lower surface as a whole clothed with minute, smooth, flattish, or slightly rounded denticles irregularly hexagonal or tetragonal in shape, and so closely crowded that the skin is entirely concealed.

Snout in front of orbits about 4.0 times as long as distance between orbits in young, about 5.0 times in large females, and 4.5 times in large males; its length in front of mouth about 3.1 times as great as width of mouth in young and 2.7–2.9 times in larger specimens of both sexes. Horizontal diameter of eye about $^2/_3$ as long as distance between spiracles, or a little longer. Length of eye plus spiracle about $^3/_4$–$^4/_5$ as great as distance between spiracles. Spiracles about $^3/_5$ as long as orbit, nearly transverse, about $^2/_3$ as long as eyes; posterior margin with two well marked folds or ridges, the outer the larger. First to fourth gill openings about equal in length, about $^1/_3$ as long as nostril, the fifth a little shorter; distance between inner ends of fifth gill openings 1.3–1.5 times as great as breadth of mouth. Nostrils moderately oblique, their length about as great as distance between them or a little greater, and somewhat more than half (57–58 %) as great as width of mouth; anterior margin expanded midway as a narrow lobe with rounded tip, curving outward and across nasal aperture and extending inward a short distance as a narrow fold that ends abruptly without encroaching on the internarial space; margins of nostril about as in *R. horkelii* (p. 58) except that digitate flap of posterior margin extends along nasal aperture about 70 % of distance toward inner corner of nostril. Mouth nearly straight with slight bow centrally, its corners with small wrinkles. Roof of mouth, close behind tooth-band, with a narrow transverse fold that widens as a low rounded lobe on either side and extends the whole breadth of mouth; its anterior surface sculptured with many low rounded prominences about equal in size to the teeth, its free edge conspicuously fringed.

Teeth in quincunx, $\frac{56-80}{51-82}$ in specimens 390–580 mm long, alike in form in the two jaws and in the two sexes; closely crowded, rectangular to pentagonal basally, with rounded corners, the functional surface a little elevated in subangular form along the transverse axis; the younger rows with a low, blunt, conical cusp which is lacking

on most of the older teeth, perhaps as the result of wear; eight to ten rows in function simultaneously in upper jaw and seven to nine in lower in large specimens.

First and second dorsals approximately equal in size, triangular, with their corners abruptly rounded, their anterior and posterior margins nearly straight and the latter approximately vertical, the free rear corners a little less than half as long as the base; origin of first dorsal posterior to tips of pelvics by a distance about equal to breadth of mouth or to extreme length of first dorsal from origin to rear corner. Interspace between dorsals about twice as long as base of first dorsal. Interspace between rear end of base of second dorsal and upper origin of caudal about 1.3 times as long as base of second dorsal. Caudal with upper origin a little anterior to lower; its upper margin weakly convex, about 1.3 times as long as interspace between dorsals, its axis only slightly raised (perhaps horizontal in some cases); its lower posterior contour well rounded without distinct lower lobe; its height above extremity of axis about as great as its depth below latter. Pelvics with weakly convex or nearly straight anterior (outer) margins, nearly straight inner margins, and weakly convex distal margins; the outer corners moderately rounded, forming an angle of about 130–135°; the posterior corners abruptly rounded, the tips much more slender in adult males than in females or in young males; extreme length of pelvics from origin to rear tip about 1.9–2.0 times as great as distance from origin of pelvics to axil; their axils separated by a distance about equal to breadth of mouth.

Rostral cartilage nearly uniform in breadth throughout most of its length but widening noticeably in somewhat rounded outline toward tip, its maximum breadth there about 1.3 times as great as distance between inner ends of nostrils, its ridges close together and approximated at tip. Anterior rays of pectorals extending anterior to nasal capsules of cranium by a distance about half as great as distance between nostrils.

Color. Ashy gray to olive brown or chocolate brown above, the area on either side of rostral cartilage pale (probably translucent in life); edges of pectorals paler than general ground tint but with a slightly darker band inward from margin; pelvics pale or whitish-edged, distinctly so in young; dorsals and caudal not noticeably darker. Typically, the entire upper surface of the disc rearward from the orbits (including posterior half of rostral ridges) is thickly freckled with several hundred small whitish dots, as is the upper surface of the tail; there are a few dots on the pelvics but none on the dorsals or caudal. But we have seen one Texas specimen with only a few pale dots and 12 others without any pale markings though agreeing with *R. lentiginosus* in other aspects. Lower surface usually pale yellow or yellowish white or plain white, the fins slightly darker than trunk, a V-shaped dusky or dark gray area below snout persisting throughout growth in some specimens but becoming diffuse in others; some specimens almost as dark in general over lower surface as above.[49] The color pattern of pale-spotted specimens is described as distinct in the young before birth.[50]

Relationship to Extralimital Species. *R. lentiginosus* is separable from all members

49. Three of the unspotted Texas specimens we have seen are dark below, the others clear white.
50. Jordan and Gilbert, Proc. U. S. nat. Mus., 5, 1883: 582.

of its genus known from the eastern side of the Atlantic by the characters summarized in the preceding Key. Among the species of the west coast of America, it differs sharply from *R. planiceps* (Garman) 1880 in having two well developed folds on the posterior margin of each spiracle;[51] from *R. glaucostigmus* Jordan and Gilbert 1883 and from *R. leucorhynchus* Günther 1866 in the fact that its rostral ridges are closely approximated along their anterior third to half. In this respect, *R. lentiginosus* more closely resembles *R. productus* Girard 1855, the common Guitarfish of southern California. But there is no likelihood of confusing the two, for the rostral cartilage is considerably narrower toward its tip in *R. productus* (maximum breadth only about as great as distance between inner ends of nostrils), the first dorsal originates considerably closer to the pelvics,[52] and the tip of the snout lacks the large tubercles that are characteristic of *R. lentiginosus*.

Remarks. All specimens of *R. lentiginosus* reported thus far from Florida and from northward on the east coast of the United States have shown the spotted pattern, as does one in our Study Material from Yucatán. On the other hand, all those from Texas that we have seen are plain-colored, except for one with a few pale dots. It may finally prove that the plain-colored and the spotted forms deserve recognition in nomenclature, whether as color varieties or possibly as subspecies. But we think it premature to burden ichthyological literature with an additional name before it is known whether the ranges of the two forms are discontinuous, or whether they meet and perhaps intergrade along the coast of Louisiana, whence one or the other of them, or both, are to be expected though not yet actually reported.

Size. This Guitarfish is said to grow to a length of "several feet,"[53] but the largest size which we find actually recorded (two females) is 30 inches. Males of 19–20 inches already have the claspers well developed (Fig. 14 C).

Developmental Stages. As noted above, the characteristic color pattern may be developed before birth. A gravid female has been recorded as containing six young.

Habits. In Florida waters, the only region where more than occasional specimens of *R. lentiginosus* have been taken, they are often encountered in shallow water around the Florida Keys and along beaches. They have even been observed at Palm Beach, Florida, moving along at low tide with "dorsals and caudals clear of the water, and every few minutes they would poke their snouts up onto the little foot-high shelf that was just wet by the small advancing and receding billows" while feeding.[54] But they are also reported as common off Florida in depths as great as 5–10 fathoms.[54] They may produce young anywhere within their geographic range, for a female with well developed embryos has been taken as far north as Charleston, South Carolina. Nothing is known of their habits beyond what applies to the genus as a whole, nor of their diet, though it is probable that when they are searching along the intertidal zone on

51. One spiracular fold only in *R. planiceps*, two in all other eastern Pacific members of the genus.

52. Origin of first dorsal is posterior to tips of pelvics by a distance only about half as great as width of mouth or a little more than half as great as length of base of first dorsal in *R. productus*, but by a distance about as great as width of mouth or about as great as extreme length of first dorsal from origin to rear corner in *R. lentiginosus*.

53. Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210.

54. Barbour, Copeia, 85, 1920: 71.

sandy beaches, as described above, they are feeding on sand-dwelling crustacea, such as gammarid amphipods, or *Hippa*.

Relation to Man. This species is neither commercially important nor of interest to anglers.

Range. Western Atlantic in coastwise waters from Yucatán to Cape Lookout, North Carolina. The great majority of published records for this species have been for captures from Florida,[55] where it occurs generally (not uncommonly by local report) along both coasts, presumably as a year-round resident. A few wander northward in spring and early summer along the Atlantic Coast, perhaps yearly, for it is "well-known to fishermen" at Charleston, South Carolina.[56] Also, it has been taken occasionally on the North Carolina Coast.[57] But there is no reason to suppose that it ever passes Cape Hatteras, except perhaps as a stray.

The northward distribution of *R. lentiginosus* along the Atlantic Coast, combined with the presence of specimens from Texas that appear to represent a color variant of it (see Study Material, p. 60), makes its occurrence probable all along the northern and northwestern shores of the Gulf of Mexico. However, present indications are that its range is as sharply limited equatorward as it is northward in the Atlantic, for the only report of it from farther south than Florida and Texas is of two specimens from Progresso, Yucatán.[58] And typical *R. lentiginosus* is so easily recognizable by its conspicuous color pattern, thorny snout, and spatulate rostral cartilage that it is not likely to have been overlooked among the representatives of its genus that have come under observation from Atlantic Panama, from Jamaica, and from Brazil (pp. 60, 71).

Synonyms and References:

Rhinobatus lentiginosus Garman, Bull. Mus. comp. Zool. Harv., *6*, 1880: 168 (descr., cf. other species, size, Florida); Proc. U. S. nat. Mus., *3*, 1881: 519 (descr., cf. other species, Florida and S. Carolina); Goode and Bean, Proc. U. S. nat. Mus., *5*, 1882: 240 (listed, Gulf of Mexico); Jordan and Gilbert, Proc. U. S. nat. Mus., *5*, 1883: 582, 619 (descr., color, female with embryos, Charleston, S. Carolina); Bull. U. S. nat. Mus., *16*, 1883: 65 (descr., Florida); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Jordan, Proc. U. S. nat. Mus., *7*, 1884: 148, 149 (listed, Florida Keys); Rep. U. S. Comm. Fish. (1885), 1887: 798 (listed, W. Indian Fauna, including Florida Keys); Lönnberg, Oefvers. Svensk. Vet. Akad. Forh., Arg. 51 (3), 1894: 111 (no. rostral spines, Florida Keys, Clearwater Bay); Henshall, Bull. U. S. Fish Comm., 14, 1895: 210 (size, Florida Keys, Tampa); Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 220 (listed, Charleston, S. Carolina southward); Bull. U. S. nat. Mus., 47 (1), 1896: 62 (descr., Charleston, S. Carolina, Florida); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (Florida); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 8, fig. 28, pl. 9, figs. 28a–28b (ill.); Evermann and Goldsborough, Bull. U. S. Fish Comm., *21*, 1902: 139 (listed, Progresso, Yucatán); Jordan, Guide to Study Fish., *1*, 1905: 551, fig. 343 (ill., Florida, S. Carolina); Smith, Bull. N. C. geol. econ. Surv., *2*, 1907: 40 (descr., ill., N. Carolina); Gill, Smithson. misc. Coll., *52* (2), 1908: 158 (body form, ill.); Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 33 (female with eggs, C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl.

55. It has been reported from Tampa, and from Clearwater Bay nearby, Captiva Pass, Lemon Bay, and Punta Rassa on the west coast, from various localities in the region of the Keys, and from Palm Beach and New Smyrna Beach on the east coast.

56. Jordan and Gilbert, Proc. U. S. nat. Mus., *5*, 1883: 582.

57. One definite report for Beaufort, North Carolina, one for Morehead City, and four specimens from Cape Lookout in July of 1912 and 1913.

58. Evermann and Goldsborough, Bull. U. S. Fish Comm., *21*, 1902: 139; see also our Study Material.

4 (3), 1913: 101 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 279, pl. 17 (descr., ill., Florida); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 98 (listed, Beaufort, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 92 (nos., size, season, C. Lookout, N. Carolina); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 269 (descr., ill., teeth, denticles, C. Lookout, N. Carolina); Barbour, Copeia, 85, 1920: 71 (habits, Palm Beach, Florida); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 70 (color, cf. *R. percellens*, not recorded for Atlant. Panama); Norman, Proc. zool. Soc. Lond., 1926: 947 (in Key), 969 (descr., ill., Morehead City, N. Carolina); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 28 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 16 (diagn., N. Carolina south); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23 (listed, Charleston, S. Carolina–Yucatán); Bere, Amer. Midl. Nat., *17*, 1936: 582 (parasites, Lemon Bay, Florida); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 98, 160 (listed, N. and S. Carolina).

Rhinobatos percellens (Walbaum) 1792

Southern Guitarfish

Figures 12C, 16

Study Material. Nineteen specimens, male and female, 210 to 591 mm long, in Harvard Museum of Comparative Zoology and U. S. National Museum, from Santos, Rio de Janeiro and Pernambuco, Brazil; Colón, Panama; and Jamaica.

Distinctive Characters. Rhinobatos percellens closely resembles both *R. lentiginosus* and *R. horkelii* in general form and in most of its proportionate dimensions. It is distinguishable from *horkelii* by its somewhat shorter nostrils; also by the facts that its crown is definitely, though only slightly, concave transversely, and that its tubercles along the midline of the back are smaller and less thorn-like in form. It differs from *R. lentiginosus*[59] chiefly in that there are no enlarged tubercles on the tip of the snout in typical specimens (several such tubercles in *R. lentiginosus*); on specimens of *percellens* that are white-spotted, the spots are not only much less numerous than on most specimens of *R. lentiginosus* but are symmetrically arranged on either side of the median line; and the rostral cartilage is narrower in *percellens* than in *lentiginosus*, especially toward the tip. We have seen three specimens intermediate between the two species: one from Texas, which has tubercles on its snout (as in *R. lentiginosus*) but has no white spots (p. 65), and two from Jamaica, sparsely white-spotted (as in *R. percellens*) but with a pair of somewhat enlarged tubercles side by side on the tip of the snout (as in *R. lentiginosus*).

Description. Proportional dimensions in per cent of total length. Male, 557 mm (Harv. Mus. Comp. Zool., No. 435) and female, 591 mm (Harv. Mus. Comp. Zool., No. 542) from Rio de Janeiro, Brazil.

Disc: extreme breadth 30.5, 32.3; length 38.8, 40.0.

Snout length: in front of orbits 14.7, 14.7; in front of mouth 16.7, 17.1.

Orbits: horizontal diameter 3.6, 3.4; distance between 3.2, 3.1.

Spiracles: length 2.2, 2.3; distance between 5.0, 5.2.

Mouth: breadth 6.3, 6.5.

Nostrils: length 3.7, 3.2; distance between inner ends 3.1, 3.4.

59. Perhaps the only significant differences that can be relied upon.

FIGURE 16. *Rhinobatos percellens*. *A* Female, from Rio de Janeiro, about 560 mm long (U. S. Nat. Mus., No. 79306). *B* Lower side of snout of another specimen of about same size (Harv. Mus. Comp. Zool., No. 435).

Gill openings: lengths, 1st 1.4, 1.4; 3rd 1.6, 1.5; 5th 1.1, 1.2; distance between inner ends, 1st 11.6, 12.3; 5th 7.7, 8.6.
First dorsal fin: vertical height 6.2, 6.8; length of base 4.7, 5.1.
Second dorsal fin: vertical height 6.5, 6.7; length of base 4.9, 5.1.
Caudal fin: upper anterior margin 15.1, 15.4.
Pelvics: origin to tip 15.1, 15.4.
Distance: from tip of snout to center of cloaca 41.8, 42.5; from center of cloaca to tip of tail 58.2, 57.5.
Interspace between: 1st and 2nd dorsals 11.3, 11.3; 2nd dorsal and caudal 6.1, 5.8.

R. percellens resembles *R. lentiginosus* so closely in appearance, in proportional dimensions generally, in shapes and locations of fins, and in the shapes of the dermal denticles on different parts of the body, that the points of difference alone need be noted. These are: Rostral cartilage narrower, less spatulate in form, its maximum breadth near tip of snout only about as great as distance between inner ends of nostrils, the two ridges close together and parallel for a little more than half their length but diverging a little rearward. Upper tip of snout without enlarged tubercles (but see p. 68). The outer of the two folds on the posterior margin of spiracle averaging a little longer relatively. Nostril 1–1.2 times as long as distance between nostrils; the inward extension of anterior nasal flap ending more abruptly, perhaps averaging a little shorter relatively (Fig. 12). White dots on upper surface much less numerous (when present) than on spotted specimens of *lentiginosus* and arranged in symmetrical pattern on both sides of midline; also, the majority of specimens more or less definitely marked with dark blotches or incomplete crossbars.

The enlarged tubercles low, either rounded transversely or with median ridge sloping forward; about 36–46 in midline of back from nuchal region to first dorsal in adults, the smaller ones irregularly interspersed with larger ones; about 3–7 in interspace between first and second dorsal fins; 1–3 on each shoulder; 3–6 close in front of orbit, with 2–7 of various sizes around inner margin of orbit to inner end of spiracle; none over outer end of pectoral girdle.

Color. Olive gray, reddish brown, or chocolate brown above; an extensive pale translucent area on either side of rostral ridges; sides usually with darker brown spots or blotches, vaguely outlined and varying in number, often forming indistinct crossbars on tail; dorsals and caudal partly dusky, but outer margins of pectorals paler than general ground tone; most specimens with up to about 40–45 indistinct whitish spots on either side of midline, about as large as pupil, irregularly distributed, but arranged symmetrically on the two sides of trunk. Lower surface pale yellowish, greyish or dusky white, the tip of the snout with a more or less conspicuous sooty blotch, either solid or more or less interrupted; diamond-shaped in young specimens but usually spreading rearward with growth along margins of head as illustrated in Fig. 16B.

Relation to Extralimital Species. Among eastern Atlantic species, *R. percellens*

resembles *R. cemiculus* the most closely. But there is no danger of confusing young specimens of the two, for *R. cemiculus* has a row of sharp spines along each rostral ridge whereas *R. percellens* does not. Older *R. percellens* appear to be separable from *R. cemiculus* by a somewhat shorter nostril relatively, by a larger number of tubercles in the mid-dorsal row (only about 17–20 in *R. cemiculus*, see p. 50, footnote 26), by somewhat more prominent spiracular folds, by somewhat lower dorsals relative to their lengths, by less prominent tubercles on the shoulders, and usually by the pale-spotted and dark-clouded upper surface (*R. cemiculus* is plain-colored above).

R. percellens, when fully grown, resembles *R. productus* of the Pacific Coast of Mexico and California, but it is separable from *R. productus* by the fact that the origin of its first dorsal is posterior to the tips of the pelvics by a distance about as great as the distance between the outer ends of its spiracles (less than half that great in *R. productus*). Less conspicuous differences are: tubercles in median row more regular in *R. percellens*, mouth a little less arched, and nostril a little shorter. Young of the two differ more noticeably; those of *R. percellens* have more numerous but much smaller mid-dorsal thorns and lack the fleshy fringe on the upper tip of the snout, a feature that is conspicuous in the young of *R. productus*. However, it is not until later in growth that the difference in the position of the first dorsal relative to the pelvics develops in the two. Also, *R. productus* is considerably the larger of the two, growing to a length of more than four feet.

Size. The claspers of one male in our Study Material, 560 mm long (about 22 in.), appear to be fully developed or nearly so. The largest specimens reported were 31[60] and about 39 inches[61] long.

Developmental Stages. A young female, 210 mm long, resembles the adult closely in general form and has 43 enlarged tubercles in the midline to the first dorsal, 10–11 between the first and second dorsals, 2–4 in front of each orbit, 3–5 around the inner orbital margin to the inner end of each spiracle, and 2–3 on each shoulder. The tubercles in the midline are more uniform in size and are rather more thorn-like in shape than in the adult, though not appreciably larger. The tip of the snout does not bear a fleshy fringe, such as that which characterizes the young of *R. productus* of the Pacific Coast of Mexico and California.

Habits. In Uruguayan waters it is taken on sandy bottom throughout the year down to a depth of 110 meters.[62] Nothing more is known of its habits.

Range. Coastal waters of the western Atlantic from northern Argentina to the Caribbean; also reported off tropical West Africa (Dahomey and mouth of the Congo).[63]

Occurrence in the Western Atlantic. This Guitarfish is generally distributed from about Lat. 38° S to the Caribbean; it has been reported from: Puerto Quequen, Mar del Plata, and Buenos Aires, Argentina; from the vicinity of Montevideo and from Maldonado, Uruguay; from Santos, Rio de Janeiro, Pernambuco, Bahia, Ilha S.

60. Müller and Henle, Plagiost., 1841: 416, as *Rhinobatus undulatus*.
61. Kner, Novara Exped., Zool., 1, Fische, 1865: 416, as *Rhinobatus undulatus*.
62. Devincenzi, An. Mus. nac. Montevideo, (2) 1 (4), 1920: 126.
63. For West African references, see Fowler (Bull. Amer. Mus. nat. Hist., 70 [1], 1936: 101).

Sebastiao at the mouth of the Amazon, and Natal, Brazil; Trinidad; Atlantic Panama; Jamaica; and the Lesser Antilles (probably St. Eustatius).

An interesting feature of its distribution is the fact that it ranges poleward nearly or quite to the 40th parallel of latitude in the southern hemisphere, where the maximum temperature for the year is only about 20–21° C (68–70° F) and where the yearly minimum may fall as low as 9–10° C (48–50° F). However, in the northern hemisphere it appears to be confined to strictly tropical latitudes and to temperatures at least no lower than about 25–26° C (77–79° F). It is replaced farther north by *R. lentiginosus* (p. 67).

Synonyms and References:

Raja percellens Walbaum, P. Artedi Genera Pisc. Emend. Ichthyol., *3*, 1792; 525 (descr., by ref. to Marcgravius [Hist.-Nat. Brazil, 1648]; Brazil).

Rhinobatus[64] *percellens* Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 63 (descr., Brazil to Jamaica); Rep. U. S. Comm. Fish. (1895), 1896: 220 (listed, W. Indies to S. Brazil); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 80 (listed, Rio de Janeiro and Rio Grande do Sul, Brazil); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 174, 207 (descr., refs.); Engelhardt, Abh. bayer. Akad. Wiss., *4* (3), Suppl., 1913: 101 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 278, pl. 55, fig. 4, pl. 56, fig. 7, pl. 65, fig. 2 (descr., ills., vertebrae, heart, skel., Rio de Janeiro); Starks, Stanford Univ. Publ., Univ. Ser., 1913: 5 (descr., color, off Natal, Brazil); Fowler, Proc. Acad. nat. Sci. Philad., *68*, 1916: 401 (listed, color); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Ilha S. Sebastiao and Santos, Brazil); Devincenzi, An. Mus. nac. Montevideo, (2) *1* (4), 1920: 126 (descr., Rio de la Plata, season); Lahille, Physis B. Aires, *5*, 1921: 63 (listed, Argentina); Meek and Hildebrand, Field Mus. Publ. Zool., 15 (1), 1923: 69 (descr., color, refs., Atlant. Panama); Ribeiro, Fauna Brasil., Peixes, *2* (1) Fasc. 1, 1923: 31, pl. 11 (descr., photos, range); Marelli, Elenc. Sist. Fauna B. Aires, Mem. Ministr. Obras Publ. B. Aires (1922–1923), Fishes, 1924: 547 (listed, Maldonado, Uruguay, Rio de la Plata and Mar del Plata, Argentina); Norman, Proc. Zool. Soc. Lond., 1926: 947 (in Key), 974 (descr., ill. head, Brazil); Devincenzi and Barattini, An. Mus. nac. Montevideo, (2) *2*, Suppl. Alb. Ictiol., 1926: pl. 3, fig. 2 (ills.); Luderwalt, Rev. Mus. paul., *16*, 1929: 40 (listed, Ilha S. Sebastiao, Brazil); Marini, Physis B. Aires, *9*, 1929: 452 (listed, Puerto Quequen, Argentina); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23 (listed, Jamaica to S. Brazil); Pozzi and Bordale, An. Soc. cient. argent., 120, 1935: 152 (Argentina, Lat. 35–40° S., depth); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 101 (descr., color, nos. teeth, Trinidad and mouth of Congo); White, Bull. Amer. Mus. nat. Hist., 74, 1937: 91 (no. heart valves, after Garman, 1913); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Jamaica; Panama); Paes de Oliveira, Ovogen. Peixes Brasil, 1, in Bol. Minist. Agric. Brazil (1943), 1945: 5 (ovary), 10 (descr.), pl. not numbered (photo, Brazil); Lopez, An. Mus. Argent. Cienc. Nat., *42*, 1947: 113 (kidney, Argentina).

Rhinobatus electricus Bloch and Schneider, Syst. Ichthyol., 1801: 356 (descr. by ref. to Marcgravius [Hist.-Nat. Brazil, 1648: 151] Brazil).

Rhinobatus glaucostictus Olfers, Die Gattung Torpedo, 1831: 22 (*glaucostictus* substituted for *electricus* Bloch and Schneider 1801 because not electric, color).

Rhinobatus undulatus Olfers, Die Gattung Torpedo, 1831: 22 (color, Rio de Janeiro); Castelnau, Anim. Nouv. Rares Amer. Sud, Poiss., 1855: 100 (listed, Rio de Janeiro); Kner, Novara Exped., Zool., *1*, Fische, 1865: 416 (descr., size, color, Rio de Janeiro); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 444 (descr., Bahia, Brazil); Garman, Proc. U. S. nat. Mus., *3*, 1880: 518 (descr., color, Rio de Janeiro southward); Cockerell, Bull. Inst. Jamaica, 1, 1892: 7 (listed, Jamaica); J. Inst. Jamaica, *1* (5), 1893: 178 (Jamaica; not seen); Berg, An. Mus. nac. B. Aires, (2) *1*, 1895: 10 (listed, Montevideo, Maldonado, Buenos Aires, Mar del Plata, nos.); Ihering, Rev. Mus. paul., *2*, 1897: 35 (listed, off Rio Grande do Sul, Brazil); Metzelaar, Trop. Atlant. Visschen, 1919: 194 (listed, trop. Atlant.).

Rhinobatus marcgravii Henle, Ueber Narcine, 1834: 34 (*marcgravii* substituted for *electricus* Bloch and Schneider 1801 because not electric).

64. Also spelled *Rhinobatos*.

Rhinobatus (*Rhinobatus*) *undulatus* Müller and Henle, Plagiost., 1841: 121, pl. 40 (descr., meas., color, ill., Bahia, Brazil); Duméril, Hist. Nat. Poiss., *1*, 1865: 498 (descr., color, Brazil).

Rhinobatus stellio Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 220 (listed, Jamaica, name only); Jordan and Rutter, Proc. Acad. nat. Sci. Philad., 1897: 91 (descr., color, Jamaica); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (3), 1898: 2750 (descr. after Jordan and Rutter, 1897, Jamaica); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Norman, Proc. Zool. Soc. Lond., 1926: 947 (in Key), 972 (descr., ill. head, Jamaica); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 23 (listed, Jamaica). Fowler, Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Jamaica).

Rhinobatus pellucens Fowler, Proc. Acad. nat. Sci. Philad., *67*, 1916: 521 (listed, Trinidad, *pellucens* perhaps misspelling for *percellens*).

Probable Synonym:

Rhinobatus undulatus Osorio, J. Sci. math. phys. nat. Lisboa, (2) *3*, 1895: 253 (listed, Dahomey, W. Afr.).

Genus *Rhinobatos* Addendum

We include here one problematical species reported from Mexico without indication as to whether it is from the Atlantic or the Pacific.

Rhinobatos spinosus Günther 1870

Study Material. None.

Knowledge of this Guitarfish is limited to the original account of a stuffed specimen 13 inches long, now in the British Museum (Natural History).[65]

Compressed spines with dilated base along median line of back, on shoulder, and above eye and spiracle; entire upper surface rough. Snout much produced, the distance between outer angle of nostrils half of that between mouth and end of snout. Anterior nasal valve not dilated laterally. Mouth nearly straight. Rostral ridges confluent, very narrow, with a small and short groove at base and provided with spines in their entire length. Snout white.

Miss Ethelwyn Trewavas contributes the additional information that the spines along the rostral ridges are thorn-like, pointing rearward, on ovoid bases, and in two irregular series, with smaller ones among and between them.

According to this description, *R. spinosus* differs from all others of its genus in the Atlantic and eastern Pacific in the fact that it continues to be spiny along its rostral ridges until it reaches such a large size—unless *R. rasus* Garman 1908[66] is distinct from *R. cemiculus* and is similarly characterized. *R. spinosus* is known at present from the original specimen only. Further discussion of it is best postponed until other specimens, Atlantic or Pacific, come under observation.

References:

Rhinobatus spinosus Günther, Cat. Fish. Brit. Mus., *8*, 1870: 518 (descr., Mexico); Garman, Proc. U. S. nat. Mus., *3*, 1880: 518 (descr. after Günther, 1870); Jordan and Evermann, Bull. U. S. nat. Mus., 47

65. Günther, Cat. Fish. Brit. Mus., *8*, 1870: 578.
66. So far known from one small specimen; see discussion, p. 54.

(1), 1896: 63 (descr. after Günther, 1870; Mexico, "probably the east coast"); Rep. U. S. Comm. Fish. (1895), 1896: 220 (listed, Mexico); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 282 (descr. after Günther, 1870).

Genus *Zapteryx* Jordan and Gilbert 1880

Zapteryx Jordan and Gilbert, Proc. U. S. nat. Mus., *3*, 1880: 53; type species, *Platyrhina exasperata* Jordan and Gilbert (Proc. U. S. nat. Mus., *3*, 1880: 32). California.

Generic Synonyms:

Syrrhina (subgenus of *Rhinobatus*) in part, Müller and Henle, Plagiost., 1841: 113.

Syrrhina Garman, Proc. U. S. nat. Mus., *3*, 1881: 521; type species, *Platyrhina exasperata* Jordan and Gilbert 1880; see discussion, p. 48, footnote 17.

Generic Characters. Disc wedge-shaped anteriorly and strongly flattened dorso-ventrally, outer pectoral margins rounded and tail stout, as in *Rhinobatos*, but disc

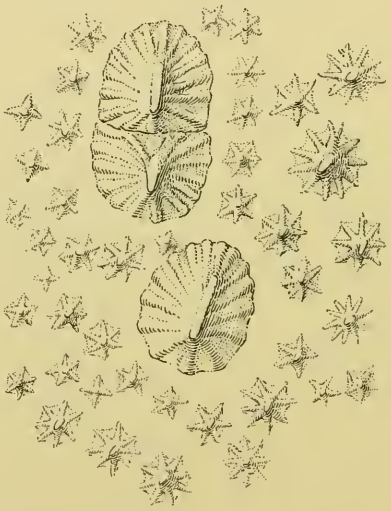

FIGURE 17. *Zapteryx exasperata*, female, 207 mm long, from San Diego, California (Harv. Mus. Comp. Zool., No. 36022). Large tubercles and smaller denticles along mid-dorsal line of disc, about 10×.

relatively broader (cf. Fig. 18 with 14, 16), so that the general appearance is more skate- or ray-like. Nostrils entirely separate from mouth and approximately transverse. Flap-like expansions of anterior margins of nostrils almost wholly covering inner halves of nasal openings and extending inward considerably beyond inner corner of nostril

(Fig. 18 C) though widely separated one from the other in the median line; posterior margin of nostril also expanded as a blunt lobe. Dermal armature much as in *Rhinobatos*, except that minute dermal denticles are thickly interstrewn with larger conical ones on upper surface; a few on lower surface also. Generic characters otherwise as in *Rhinobatos*.

Size. Maximum length about three feet.

Habits. Similar to those of *Rhinobatos*, so far as is known.

Range. Known only from Brazil and along the Pacific Coast of America from southern California and the Gulf of California southward to Panama.

Species. Only two, the one Atlantic, the other Pacific.

Key to Species

1a. Dorsal fins with posterior margins longer than their bases; rostral ridges converging anteriorly; small denticles on dorsal surface posterior to nuchal region rising gently rearward or even nearly horizontal, their bases irregularly scalloped, not regularly stellate or striate (Fig. 19 B).
brevirostris Müller and Henle 1841, p. 75.

1b. Dorsal fins with posterior margins shorter than their bases; rostral ridges nearly parallel; small scales on dorsal surface conical, erect, their bases conspicuously striate or stellate (Fig. 17). *exasperata* Jordan and Gilbert 1880. Pacific Coast of America, southern California to Panama.

Zapteryx brevirostris (Müller and Henle) 1841

Short-nosed Guitarfish

Figures 18, 19

Study Material. Four females, 445 to 480 mm long, and a juvenile male, 345 mm, from Brazil, in Harvard Museum of Comparative Zoology.

Distinctive Characters. The heart-shaped disc of *Zapteryx*, combined with its stout muscular tail bearing two large dorsal fins, marks it off from all other batoids known from the western Atlantic except for the three local Guitarfishes, *Rhinobatos horkelii*, *R. lentiginosus* and *R. percellens*. It is separable from these by its much more obtuse snout and relatively broader disc, together with the fact that the flap-like expansions of the anterior margins of its nostrils almost wholly roof over the inner half of the nasal apertures.

Description. Proportional dimensions in per cent of total length. Male, 345 mm, and female, 460 mm (Harv. Mus. Comp. Zool., No. 536) from Rio de Janeiro, Brazil.

Disc: extreme breadth 47.3, 48.7; length 42.2, 41.7.

Snout length: in front of orbits 9.0, 9.4; in front of mouth 11.9, 12.0.

Orbits: horizontal diameter 4.4, 3.7; distance between 4.8, 4.1.

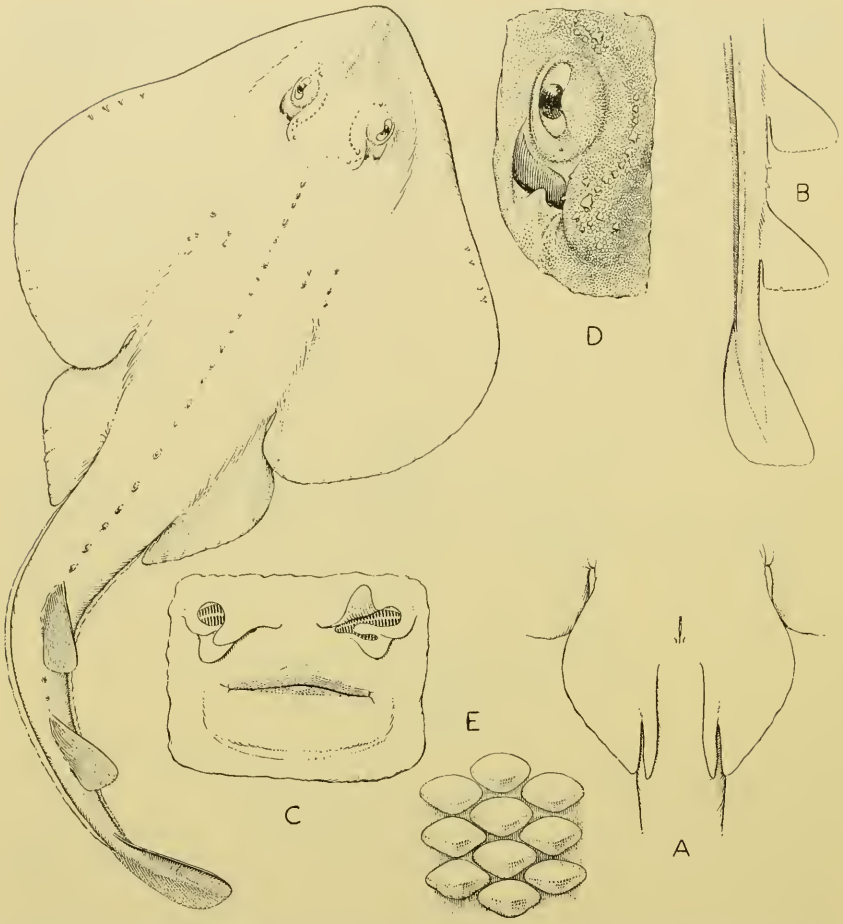

FIGURE 18. *Zapteryx brevirostris*, immature male, about 345 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 536). *A* Ventral view of pelvics. *B* Lateral view of tail. *C* Mouth and nostrils, about 1×. *D* Eye and spiracle, about 1.5×. *E* Upper teeth, about 18×.

Spiracles: length 2.8, 2.6; distance between 7.0, 6.5.
Mouth: breadth 7.2, 7.2.
Nostrils: distance between inner ends 4.1, 3.7.
Gill openings: lengths, 1st 1.7, 1.9; 3rd 1.6, 1.7; 5th 1.3, 1.3; distance between inner ends, 1st 15.7, 15.2; 5th 12.2, 12.2.

First dorsal fin: vertical height 7.6, 7.4; length of base 5.1, 5.0.
Second dorsal fin: vertical height 7.3, 7.2; length of base 5.7, 5.6.
Caudal fin: upper anterior margin 13.7, 13.1.
Pelvics: origin to tip 17.4, 18.5.
Distance: from tip of snout to center of cloaca 41.8, 44.3; from center of cloaca to tip of tail 58.2, 55.7.
Interspace between: 1st and 2nd dorsals 7.8, 8.0; 2nd dorsal and caudal 6.7, 5.4.

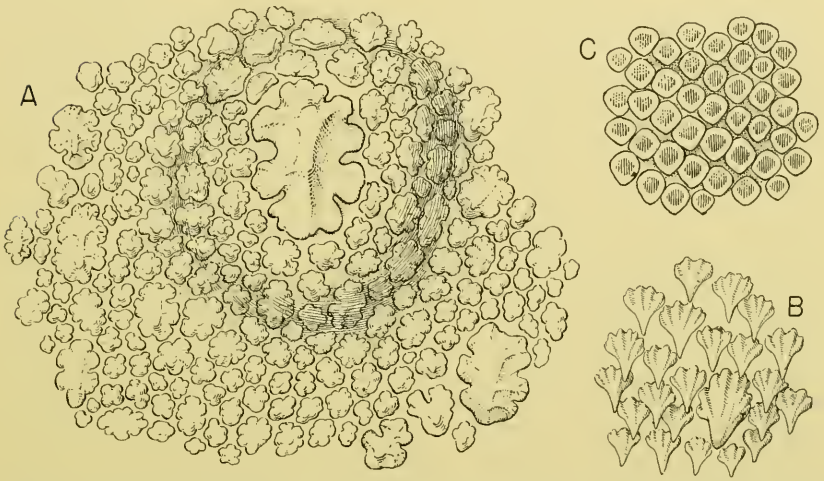

FIGURE 19. *Zapteryx brevirostris*. *A* Large tubercle and smaller dermal denticles on right-hand shoulder of specimen illustrated in Fig. 18, 17×. *B* Dermal denticles from side of tail of female, 450 mm long, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 429), about 30×. *C* Dermal denticles from lower surface of abdomen of same, about 30×.

Disc a little broader (1.1) than long, heart-shaped, its anterior angle to level of fronts of orbits about 105–107°; anterior margins weakly convex opposite eyes, slightly concave opposite spiracles in young specimens and in adult females, but somewhat more deeply so in mature males;[67] posterior corners broadly rounded, posterior margins moderately so; posterior corners of pectorals overlapping pelvics by a distance about as great as that between exposed nostrils. Tail from center of cloaca longer (1.2–1.4) than distance from center of cloaca to tip of snout, about as broad opposite axils of pelvics as distance between outer ends of spiracles; tapering evenly rearward; flattened below and moderately rounded above, each side with a longitudinal dermal fold extending from just posterior to tips of pelvics to a little beyond origin of caudal.

Dermal denticles on dorsal surface close-set but with skin exposed between; those

67. It is so shown in Ribeiro's (Fauna brasil., Peixes, *2* [1] Fasc. 1, 1923: pl. 12) photograph of a male with large claspers.

on head, on midzone of back, and on tail, low, conical to pyramidal, with irregularly fluted bases; those over pectorals as a whole more scale-like and raised but little from the skin, with sharp points and usually with two longitudinal ridges; interspersed among these (most numerous over inner parts of pectorals and along sides of anterior part of tail) are considerably larger denticles, ranging in form from blunt-conical to blunt-pyramidal, their bases fluted anteriorly. Midline of back, from nuchal region to origin of first dorsal, with an irregular row of 21–23 domed prominences, fluted basally and covered with small rounded denticles, a larger rounded tubercle (similarly fluted) emerging from the tip; between first and second dorsals, two or three similar but smaller prominences, with tubercle at tip; two series of tubercles on each shoulder, the inner series of two, the outer series of two or three; eight to ten along posterior part of each orbital ridge (decreasing in size anteriorly), with a larger one on anterior margin of orbit; a row of four to eight pyramidal tubercles along outer margin of each pectoral a little anterior to axis of greatest breadth in some specimens.[68] Lower surface closely clothed with small flattish denticles, irregularly quadrate or hexagonal, with rounded corners.

Snout in front of orbits about 1.9–2.2 times as long as distance between orbits, its length in front of mouth about 1.6–1.7 times as great as width of mouth and about 3.0–3.2 times as great as distance between inner ends of nostrils. Crown concave transversely, the margins of orbits prominent. Horizontal diameter of eyes between $^1/_4$ and $^1/_5$ (about 21 %) as long as snout in front of orbits. Length of eye plus spiracle about half as great as distance between spiracles. Spiracles about $^3/_5$ as long as orbits, moderately oblique, their inner ends directed rearward, with one low ridge on posterior margin. First pair of gill openings (the longest) a little more than half as long as nostrils, the second to fifth pairs a little shorter in succession; distance between inner ends of fifth pair about as long as snout in front of mouth. Nostrils transverse or slightly oblique; length about as great as distance between nostrils (95–100 %) and a little less than half as great as width of mouth; anterior margin expanded as a broad rounded flap almost wholly covering inner half of nasal aperture and continuing inward as a narrow fold with rounded lobular termination on internarial space, about halfway toward midline; posterior margin of nostril with two flap-like expansions directed rearward toward mouth, the outer narrower, the inner broadly rounded; also a narrower and longer intervening lobe directed across nasal aperture. Mouth only slightly bowed, its corners wrinkled but without extensive pits or furrows.

Teeth $\frac{64-72}{64-70}$, low, those of females and of young males ranging from weakly rounded to nearly flat, without cusp, closely crowded in quincunx arrangement; about 10 rows in function simultaneously in center of mouth in upper jaw and about 12 rows in lower; those of sexually mature males not seen.

First and second dorsals about equal in size, triangular, with narrowly rounded apex and weakly convex anterior and posterior margins, the latter nearly vertical; free rear basal margins about half as long as base. Origin of first dorsal posterior to level

68. A male and two females have these, but two other females lack them.

of axils of pelvics by a distance about half as great as distance from origin of first dorsal to origin of caudal and about as long as interspace between the two dorsals. Interspace between first and second dorsals about 1.5–1.6 times as long as base of first dorsal. Interspace between base of second dorsal and origin of caudal about as long as base of second dorsal. Upper and lower origins of caudal about opposite one another; caudal axis horizontal or bent slightly upward; upper margin nearly straight and nearly as long as distance from origin of first dorsal to origin of second; lower posterior margin evenly rounded, without separate lower lobe; height of caudal above termination of axis about 1.3 times as great as depth below the latter. Pelvics broadly rounded outwardly, decreasing to narrowly blunted tips, their inner margins weakly concave, their extreme length from origin to tip about twice as great as length of interspace between first and second dorsals; their axils separated by a distance about as great as breadth of mouth in females, but only about $^3/_4$ that great in juvenile male. Claspers of mature male slender, as in *Rhinobatos*, their tips somewhat swollen, extending back about to level of rear end of base of first dorsal.

Rostral cartilage broad basally, tapering anteriorly to narrow tip close to extremity of snout; its lateral ridges low, inconspicuous, far apart at base but converging toward tip. Anterior rays of pectorals extending for only a short distance anterior to level of front of orbital region of cranium, thus falling far short of extremity of snout.

Color. Preserved specimens olive to brownish gray above, without definite markings; dorsals and caudal somewhat darker than general ground tint; margins of pectorals and pelvics paler; space on either side of rostral cartilage also pale, possibly translucent in life. Lower surface grayish or yellowish white, the posterior corners of pectorals and tips of pelvics more or less dusky.

Size. The largest specimen recorded was about 21 inches long (540 mm),[69] but it is not unlikely that *Z. brevirostris* may reach as great a size as *Z. exasperata* of the Pacific, a length of about three feet.[70]

Developmental Stages. It is probable that development is ovoviviparous, but neither the embryos nor the newborn young have been reported.

Habits. Nothing whatever is known of the habits of this Ray to distinguish it from the Guitarfishes of the genus *Rhinobatos*.

Range. Known so far from Brazil alone, where it has been taken near Rio de Janeiro and near Bahia. Apparently it is not common though occasionally trawled in some numbers.

Synonyms and References:

Rhinobatus (*Syrrhina*) *brevirostris* Müller and Henle, Plagiost., 1841: 114, 192, pl. 36 (descr., meas., ill., Brazil); Castelnau, Anim. Nouv. Rares Amer. Sud, Poiss., 1855: 100 (listed, Rio de Janeiro); Duméril, Hist. Nat. Poiss., *1*, 1865: 489 (descr., size, Brazil).

Platyrhina sinensis (in part) Gray, List Fish. Brit. Mus., *1*, 1851: 98 (specimen from Brazil, but not refs.).

Rhinobatus brevirostris Günther, Cat. Fish. Brit. Mus., *8*, 1870: 447 (descr., size, Brazilian specimen pre-

69. Duméril, Hist. Nat. Poiss., *1*, 1865: 490.

70. Ribeiro (Fauna brasil., Peixes, *2* [1] Fasc. 1, 1923: pl. 12) gives an excellent photograph of a male with fully developed claspers but without stating the size.

viously listed by Gray, 1851, as *Platyrhina sinensis*); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 80 (listed, Rio de Janeiro); Ribeiro, Pescas 'Annie,' 1904: 18 (nos., Ilha Rasa, Brazil); Arch. Mus. nac. Rio de J., *14*, 1907: 175, 207 (diagn., refs., Rio de Janeiro and Bahia, Brazil); Fauna Brasil., Peixes, *2* (1) Fasc. 1, 1923: 31, pls. 12, 13 (diagn., photos, male and female, Rio de Janeiro and Bahia, Brazil).

Syrrhina brevirostris Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 89, pl. 25 (mucous canals); Mem. Harv. Mus. comp. Zool., *36*, 1913: 285, pl. 65, fig. 3 (descr., ill. skel., Rio de Janeiro).

Zapteryx brevirostris Norman, Proc. zool. Soc. Lond., 1926: 943 (in Key), 980, fig. 1E (ill. nostril, size, refs. Brazilian specimen in Brit. Mus.).

Suborder TORPEDINOIDEA

Electric Rays, Torpedo Rays

Characters. Trunk anterior to cloaca a depressed subcircular disc, fleshier toward its margins and thicker there than in most other disc-shaped batoids, the body softer. Tail rather sharply marked off from body sector, with or without lateral folds; broader basally than in any other batoids except the Sawfishes (Pristoidea) and Guitarfishes (Rhinobatoidea); as long as body in some, but shorter than body in most, and reduced in some to a mere rudiment bearing the fins.[1] Attachment of anterior parts of pectorals to sides of head extending forward to or beyond level of eyes. One or two well developed dorsal fins, or none; the first (if there are two) partly over or close behind bases of pelvics. Caudal fin well developed, its axis raised but slightly if at all. Pelvics with outer margins continuously convex in most cases but somewhat emarginate in some, so deeply so in one genus that the anterior subdivision forms a separate limb-like structure arising from the lower surface of the disc some distance inward from the margin[2] (as in some genera of Rajoidea also, pp. 314, 327). Inner posterior margins of pelvics free from sides of tail in some species but united with it in others.

Eyes small, functional in most species, but rudimentary or even entirely obsolete in a few deep-water forms. Spiracles either close to eyes or separated from the latter by a narrow interspace, their margins either smooth or with larger or smaller knobs or papillae. Nostrils close to mouth but entirely separate from it, their anterior margins expanded and joined together as a single curtain-like flap with median attachment roofing over inner parts of nasal openings and extending rearward nearly or quite to the mouth. Mouth small to moderate in size; widely distensible in some genera, with the upper and lower jaw cartilages but loosely articulated together; more or less protractile in others, with the jaws not only firmly articulated but also bound together on either side by a labial cartilage of two elements with special muscles, thus limiting the gape (see also p. 108). Gill openings small. Teeth small, rounded, or with one to three more or less prominent cusps; in 12 to about 64 series in different species, arranged in bands that terminate some little distance short of either corner of mouth;

1. Genus *Hypnos*, p. 87.
2. This is the case in *Typhlonarke*, a genus of Narkidae (i. e., with one dorsal fin), founded by Waite (Rec. Canterbury [N. Z.] Mus., *1* [2], 1909: 146) for an Electric Ray first described as *Astrape aysoni* Hamilton (Trans. N. Z. Inst., *34*, 1902: 25, pls. 10–12).

several rows in function simultaneously; the integument bearing the tooth bands firmly attached to jaw cartilages in some, only loosely so in others.

Skin soft and entirely naked in most species, but with margins of pectorals described as having small papillae "partly spinous" in one.[3]

Rostral projection of cranium single or double and more or less branching in some; reaching to anterior margin of disc. Antorbital cartilages extending forward to support front of disc, their anterior margins dissected in complex fashion in some species but less so in others, and spreading laterally to anterior rays of pectorals or even overlapping latter.[4] Extremities of branchial rays widely expanded as plate-like discs. Dorsal and caudal fins supported basally by short cartilaginous radials, distally by much more numerous fine horny rays (ceratotrichia) in double series. Pectoral and pelvic fins without horny rays, the cartilaginous radials extending outward to margins. Pelvis (in species studied) bowed rearward, with a well developed lateral process extending forward at either end. Margins of gill arches smooth inward from gill filaments. Electric organs well developed, between sides of head and forward extensions of pectorals.

Electric Organs. The anatomy and physiology of the electric organs of the Torpedo Rays, as well as of those of other fishes, and the characteristics of the electric currents generated by them, have been the subject of much research, resulting in extensive literature.[5] Each of the two organs of an Electric Ray occupies one side of the anterior part of the disc between the anterior extension of the pectoral and the head, extending forward about to the level of the eye and rearward past the gill region to the vicinity of the pectoral girdle. Together the two organs comprise about one-sixth of the total weight of the fish in each of the two western Atlantic species (*Torpedo nobiliana* and *Narcine brasiliensis*) for which this relationship has been determined. In most cases the outlines of the organs are visible externally on the ventral side and usually faintly so on the dorsal side as well, where, however, they are more hidden from view by the pigmentation of the skin.

Numerous columnar structures, separated by loose fibrous tissue, make up each organ and occupy the entire thickness of the disc from the upper to the lower integument, their lengths decreasing toward the periphery as the disc becomes thinner. These columns, often referred to as "prisms," have been described repeatedly and have been pictured more or less diagramatically as arranged like the cells of a honeycomb.[6]

3. *Torpedo mackayana* Metzelaar (Trop. Atlant. Visschen, 1919: 197).
4. For a recent discussion of the head skeleton and comparison with other batoids, see Holmgren (Acta Zool. Stockh., *22*, 1941: 57, *65*, *66*).
5. For general summaries of results and references, see Gotch (in Shafer, Text Bk. Physiol., 1900: 561–591) and especially Garten (in Wintersheim, Handb. Vergl. Physiol., *3* [2], 1910–1914: 172ff). For more detailed accounts, see Gotch (Philos. Trans., [B] *178*, 1888: 487–537; [B] *179*, 1889: 329–363), Schoenlein (Z. Biol., *31*, N. S. *13*, 1895: 449–523), Fuji (J. Coll. Sci. Tokyo, *37*, 1914: 1), as well as Coates and Cox (Zoologica N. Y., *27*, 1942: 25), and Cox and Breder (Zoologica N. Y., *28*, 1943: 45) for observations on the discharges of *Torpedo nobiliana* and of *Narcine brasiliensis* respectively.
6. For semidiagrammatic illustrations of the arrangement of the columns in various species, see especially Fritsch (Elektr. Fische, *2*, 1890: pls. 3–15). For a more realistic illustration of their actual appearance in *Torpedo* when exposed to view, see Jobert (Appar. Electr. Poissons, 1858: pl. 1, figs. 1–3).

Actually, however, it is a matter of common knowledge that they are more loosely aggregated than the foregoing would suggest (Fig. 25F) and that they vary in cross section from hexagonal with rounded corners to roughly circular. The number of columns in a single organ ranges from as few as 140–150 in some genera (*Temera* and *Discopyge*) up to an average of 1,025–1,083 for *Torpedo nobiliana*.[7]

Each column is divided by transverse partitions into a large number of so-called electric discs, each consisting of a clear jelly-like mass that includes a number of large nuclei and each being separated from its neighbors by a connective tissue layer through which run the nerve fibers and blood vessels. Since there may be 375 or more discs per column, their total number in the larger species[8] is in the hundreds of thousands for each organ. It has been stated that both the final number of columns in the organ and the numbers of electric plates per column are established before birth. But a slight increase in the number of columns takes place with growth, 267, 276, and 315 having been counted for each organ on three embryos of *Narcine brasiliensis* from Florida, 250, 382, and 409 for three adults. Also, it has been found that the number of plates per column varies according to the length of the column; in one embryo of *Narcine brasiliensis* the average counts were 305 near the inner and thicker edge of the organ but only 179 per column near the outer and thinner edge; the counts were 482 and 288 respectively in the organ of another.[9]

The nerve supply to the electric organs is highly developed, each organ receiving one branch of the trigeminal nerve and four branches of the vagus nerve; the former and the three anterior branches of the latter are as thick as the spinal cord and all arise together from a special lobe of the brain known as the "lobus electricus." Distally, these nerves branch again and again and terminate in a cluster of fine fibrils on the ventral connective tissue wall of each electric plate. It has been found that the ventral sides of the plates are negative (electrically speaking) to the dorsal sides, and that the lower side of each electric organ as a whole is negative, thus representing the plus or anode pole of what appears to be a form of multiple concentration cell. In other words, the discharge produced by the organ as a whole passes through the latter from the ventral side toward the dorsal, whereas in an Electric Eel (*Electrophorus*) it runs through the organ from the tail toward the head, in an Electric Catfish (*Malopterurus*) from front to rear. All parts of a single organ, and the two organs as well, discharge almost simultaneously, and it has been observed repeatedly that the discharge is accompanied by slight muscular contractions of the disc, cupping the margins of the latter upward.

The ability of Electric Rays to produce shocks was "well known to the ancient Greeks and Romans,"[10] and it has been known for many years that the discharge has

7. For a table of average numbers of columns in different species, see Fritsch (Elektr. Fische, *2*, 1890: 97; *nobiliana* listed as "*hebetans*"); also Ballowitz and Schmidt (in Bolk and others, Handb. Vergl. Anat. Wirbelt., *5*, 1938: 669).
8. The number per organ for a specimen of the European *Torpedo marmorata* was 179,625, as calculated by Fritsch (Elektr. Fische, *2*, 1890: 102). It may reach 500,000 in large specimens of other species of the genus.
9. Cox and Breder, Zoologica N. Y., *28*, 1943: 46.
10. For further details, see Norman and Fraser (Giant Fishes, 1937: 66).

all the properties of electricity, being capable of producing a spark, of deflecting or magnetizing a needle, of electrolyzing chemical compounds (e. g., of dissociating iodide of potassium), and so forth; also, it is audible on a telephone suitably connected.

It is commonly said that the production of the shock is under the voluntary control of the Torpedo, both as to time of discharge and as to its strength. Electric Rays, lying undisturbed on the bottom of an aquarium, have been observed (by telephone) to give off a succession of discharges spontaneously; i. e., without any apparent stimulation.[11] However, the regularity with which a discharge follows when the skin is touched or otherwise stimulated suggests that it is chiefly a simple reflex action induced by tactile stimulation. It has long been known that the fish lies quiet for some little time without further discharge after delivering a shock, and the delivery of several discharges at rather brief intervals leaves it in an exhausted condition, after which it requires a considerable rest period before it can discharge again. We may cite the case of an Australian specimen of *Hypnarce* that delivered 50 successive shocks within about ten minutes, intense at first but weakening until hardly discernible.[12] And it has been observed in laboratory experiments that the voltage and power decline rapidly as the fish becomes increasingly fatigued.

The individual discharges or pulses, each lasting perhaps 0.03 second, follow one another in rapid succession[13] in trains. In *Torpedo nobiliana* of the western Atlantic, the number of pulses per train appears to average about 12 but may go as high as 100, exceptionally more than that. Either one train, or a few trains following one another in rapid succession, constitute what is commonly termed a "shock." The electromotive force of the discharge varies not only from species to species and from specimen to specimen of a given species but with the condition of the fish, while differences in recorded results are partly to be explained as due to differences in the sensitivity of the apparatus employed. Measured voltages range from as low as 8–17[14] to as high as 70–80[15] for the European *Torpedo marmorata*, with estimates going as high as 200.[16] Seven to 37 volts, with various resistances, have been recorded for *Narcine brasiliensis*; 25 volts was recorded for one specimen of *Torpedo nobiliana* and 220 volts for another of about the same size, a divergence which illustrates the differences in the electric capabilities of different specimens of the same species.[17] This last voltage (220), which probably approximates the maximum to be expected from any Electric Ray, is about equal to that of the Electric Catfish (*Malopterurus*) of North African rivers but falls considerably below that of the so-called Electric Eel (*Electrophorus*) of South America.

The literature on the Electric Rays includes almost endless references, from classic times down to the present, pertaining to the effects of the shocks received by

11. Schönlein, Z. Biol., *31* (N. S. *13*), 1895: 451.
12. McCulloch, Aust. Mus. Mag., *1* (3), 1921: 89.
13. Rates reported as being up to 150 per second.
14. d'Arsonval, C. R. Acad. Sci. Paris, *121*, 1895: 145.
15. Cremer, Verh.Gesell. dtsch. Naturf., Ärt. *80*, samml. Cologne, 1909 (2), 2 hälf. 2 grup.: 523.
16. Gotch and Burch, Proc. roy. Soc. Lond., *65*, 1900: 442.
17. See Coates and Cox (Zoologica N. Y., *27*, 1942: 28) and Cox and Breder (Zoologica N. Y., *28*, 1943: 49) for tabulations of voltage, current, and power for *Torpedo nobiliana* and *Narcine brasiliensis*.

persons who have come in contact with them in one way or another. The following is an interesting first-hand account of such an experience in Australia.

> Whilst wading at Gunnamatta Bay I trod on an electric ray and it was as if a large hand clutched my foot and ankle. I netted the specimen and put it on a sand bank. Here I noticed a black leech between its eyes, and in trying to knock this off with my net got a more severe shock, which so suddenly contracted the muscles of my arms and legs that I leapt a foot in the air.[18]

Indeed, the shock from a large one in rested condition is strong enough to knock down and temporarily disable a full-grown man (p. 102). So Electric Rays might even be dangerous to bathers who accidentally step on them as they lie buried in the sand in the shallow water of regions where the larger sizes are common enough for this to be a likely occurrence.

It has been stated that Torpedoes are immune to their own shocks. But it seems that they are not wholly so, for it has been observed that the discharge is accompanied by a slight and brief muscular contraction, as noted before (p. 82), this apparently resulting from the reception of its own discharge.[19] It has been argued that their apparent immunity results, in reality, from the weakening of the electric discharge as it passes through the water.[20]

The requirement that the recipient of a shock must complete the circuit by making contact with the fish at two points, whether directly or indirectly, is fulfilled in the normal life of the Ray by means of the surrounding sea water. This has been illustrated experimentally with the recording of the shock by telephone, one pole of which is in metallic contact with the Torpedo, the other pole (also metallic) in the water at a distance not greater than 20 cm (8 in.) from the fish.[21] It is only if an Electric Ray is out of water, as when lying on the dry planks of a dock, that the mechanical two-point contact is requisite. And even in such cases it has been found that "quite a powerful sensation of numbness can be produced through the medium of a stream of water, that is to say, by pouring water onto a living fish."[22]

The disabling effect that shocks by Torpedoes may be expected to have on small animals that may come in contact with them has given rise to a general belief that electric organs of the Torpedo normally serve a defensive purpose. Although it has been questioned recently whether the organs are of much importance in this respect,[23] it has been observed in the Naples Aquarium that crayfish, crabs, and cephalopods are greeted by discharges if they chance to touch a *Torpedo marmorata* lying on the bottom. Indeed, one was seen to drive off a large octopus in this way.[24] However this may be, it seems probable that the shocks do serve more or less to stun the prey, for wholly uninjured fishes, so large that it seems hardly conceivable that they could have been swallowed unless they had been rendered helpless beforehand, have been found in the

18. Whitley, Fish. Aust., *1*, 1940: 165.
19. Jobert and Jolyet, Trav. Lab. Soc. sci. Arcachon (1895), 1896: 57.
20. Schönlein, Z. Biol., *31* (N. S. *13*), 1895: 512.
21. Schönlein, Z. Biol., *31* (N. S. *13*), 1895: 450.
22. Norman and Fraser, Giant Fishes, 1937: 65.
23. Lübbert and Ehrenbaum, Handb. Seefisch. Nordeurop., *2*, 1936: 317.
24. Schönlein, Z. Biol., *31* (N. S. *13*), 1895: 450, 453.

stomachs of Torpedoes. On the other hand, it has been noted that small fishes (Gobies) and invertebrates placed on the head and fins of a large Australian species, *Hypnos monopterygium* (Shaw and Nodder) 1795, which is capable of delivering a shock of considerable intensity, "seemed to suffer no ill effects, though they must have received shocks."[25] Even if some species of Torpedo Rays do numb their prey to some extent by electric discharges, it is not likely that they are limited in their feeding to victims that have been partially incapacitated in this way, for at least some fishes are so resistant to currents passing through sea water that the Ray would actually have to come in contact with them for its discharges to have any disabling effect. Invertebrates, it seems, are more susceptible to the effect of the discharge.

Size. The largest members of the genus *Torpedo* grow to a length of five or six feet and, according to reports, may reach a weight of 200 pounds (p. 101); the blind genus *Typhlonarke* (p. 80) probably reaches a length of at least four feet. At the opposite extreme, the greatest length attained by some members of the genus *Narke* may be less than one foot.

Development. They are ovoviviparous; the European *Torpedo marmorata* is one of the Rays on which the development of the pectorals (leading to their attachment to the sides of the head) has been traced (p. 101).[26]

Habits. The Electric Rays prey more or less indiscriminately on various crustaceans, mollusks, worms, and other invertebrates, as well as fishes (p. 102), some of the latter so large that it is a puzzle how the Rays manage to swallow them. A specimen of the Mediterranean *Torpedo marmorata*, lying on the sand in an aquarium, has been seen to raise the front of its disc while keeping the margins pressed down, thus forming a cavity into which small fish were swept by the inrush of water. In one instance a small shark emerged again undamaged, but in another a mullet was not seen again, probably having been captured.[27]

Sluggish in habit and feeble swimmers, they lie on the bottom most of the time, partially buried in sand or mud. The group as a whole covers a wide bathymetric range, for while most of its members occur in rather shallow water and some even survive stranding for some hours in the intertidal zone,[28] others (genus *Benthobatis*) are confined to at least moderately great depths (p. 127).

Range. The geographic range of one Electric Ray or another extends to all the oceans, including the Mediterranean, and covers the temperate, subtropical, and tropical belts. In the Atlantic they occur northward regularly to southern New England in the west and to northern Scotland (Moray Firth and Wick Bay) in the east, southward to southern Argentina in the west,[29] and to the southern extremity of the

25. Whitley, Fish. Aust., *1*, 1940: 165.

26. For illustrations of successive stages in the embryonic development of the European *Torpedo marmorata*, see especially Fritsch (Elektr. Fische, *2*, 1890: pl. 15, figs. 38–43) and Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 61, figs. 1–3).

27. Schönlein, Z. Biol., *31* (N. S. *13*), 1895: 453.

28. The Australian genus *Hypnos* has this ability (Whitley, Fish. Aust., *1*, 1941: 166), although its vertical range also extends down to at least 120 fathoms.

29. The most southerly record of any Electric Ray on the Argentine Coast with which we are acquainted is from Lat. 46° 18′ S (Norman, 'Discovery' Rep., *16*, 1937: 11, 12).

African continent (Table Bay) in the east. In the eastern side of the Pacific they are known from the State of Washington in the north to middle Chile in the south and in the western side from Japan southward to New Zealand, southern Australia and Tasmania. They are also distributed generally through the East Indies and all around the coasts of the Indian Ocean, including the Arabian Sea, the Persian Gulf, and the Red Sea, southward to southern Africa. In view of this wide distribution and of the evident tolerance of the group as a whole to a wide range of temperature and depth, the apparent failure of any of the Electric Rays to have colonized any of the oceanic island groups of the tropical Pacific[30] presents something of a puzzle.

Relation to Man. None of the Electric Rays is of any commercial value at present, nor are they ever likely to be, for their flesh is soft and flabby and it is reported to be tasteless. But years ago, before the use of kerosene oil, the liver oil of *Torpedo nobiliana* of the western Atlantic was considered equal to the best of sperm oil for illuminating purposes. According to classical writers, they were used to some extent as food by the ancient Greeks and Romans; also their shocks were remedies for disease of the spleen, for chronic headaches, and for gout; their brains, mixed with alum, were used as a depilatory, and the presence of a Torpedo within the room was considered a sure stimulus to easy delivery for a pregnant woman.[31]

Families. The Electric Rays commonly have been united in a single family following a precedent established more than a century ago.[32] But by 1865 those with two dorsal fins, those with one, and those with none had already been distributed among three corresponding (unnamed) groups,[33] which have been treated recently as the subfamilies Torpedininae, Narkinae, and Temerinae respectively.[34] This arrangement has not only the disadvantage of separating genera that resemble each other closely in other respects but of running counter to a dichotomous grouping based on the firmness of articulation of the upper and lower jaws and the presence or absence of labial cartilages, characters which are probably of greater importance phylogenetically than the number of dorsal fins. However, in a general work such as this it would be premature to adopt the structure of the jaws as the chief distinguishing character for families until conditions in this respect are known for a larger proportion of the genera involved.[35] The scheme based on the number of dorsal fins is followed here as a matter of convenience, though we expect that it will be abandoned eventually in favor of the alternate scheme based on the jaws.

Key to Families

1a. Two dorsal fins. Torpedinidae, p. 87.

30. Or at least the failure of ichthyologists to have encountered them there.
31. For a readable account of early knowledge of the Electric Rays, and for classical references to them, see Couch (Fish. Brit. Isles, *1*, 1867: 121–124) and Radcliffe (Fishing from Earliest Times, 1921: 181, 281, 282).
32. Müller and Henle, Plagiost., 1841. 33. Duméril, Hist. Nat. Poiss., *1*, 1865: 504.
34. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 332.
35. Out of a total of nine known genera of Electric Rays, the presence of labial cartilages that connect the two jaws has been established definitely for five genera (*Benthobatis*, *Narcine*, *Diplobatis*, *Discopyge*, and *Narke*), and their absence has been determined for two (*Torpedo* and *Hypnos*).

1b. One dorsal fin or none.

2a. One dorsal fin. — Narkidae.
Indian Ocean in general, South Africa and Natal to India, Malaysia, East Indies, southern China to Japan, and New Zealand.

2b. No dorsal fin. — Temeridae.
Malay Peninsula and Cochin-China.

Family TORPEDINIDAE

Characters. Disc ranging from subcircular to elongate. Tail sector as long as body sector or shorter, with or without lateral folds. Two dorsal fins, both of them well developed. Tips of pelvics either separate from sides of tail or united to latter. Eyes either well developed, with evident pupil, or obsolete. Nostrils either simple or subdivided by a cross bridge; separate from mouth, but connected by a groove with furrow surrounding mouth in some species. Mouth protractile as a short tube and with labial cartilages in some genera, but widely distensible and without labial cartilages in others. Characters otherwise those of the suborder.

Remarks. The members of this family vary widely in general form, in length of tail relative to that of disc, in the condition of the eyes (i. e., whether comparatively large and fully functional or obsolete or nearly so), and in the extent to which the inner margins of the pelvic fins are united with the sides of the tail. They also cover the entire distributional range of the suborder, bathymetric as well as geographic.

Key to Genera

1a. Mouth widely distensible (Fig. 20) but only slightly protractile; upper and lower jaw cartilages not bound together at corners of mouth by labial cartilages, their lateral articulation loose; tooth bands firmly connected with jaw cartilages.

2a. Tail from tips of pelvics about as long as breadth of mouth when latter is closed, its length from center of cloaca to termination only about $^1/_3$ as great as distance from cloaca to snout; teeth with two or three cusps.
Hypnos Duméril 1852.[36]
New South Wales, Queensland, and West Australia.

2b. Tail from tips of pelvics more than three times as long as breadth of mouth

36. Waite (Rec. Aust. Mus., *4*, 1902: 180) proposed the name *Hypnarce* to replace *Hypnos*, on the ground that that name had been preoccupied by *Hypna* Hübner 1818, for Lepidoptera. But this substitution appears not to be required under the International Rules of Zoological Nomenclature, as now accepted. *Hypnarea* Sharp (Zool. Rec., *39*, Index, 1903: 9) appears to have been a misprint, the reference being to *Hypnarce* Waite 1922. Whitley (Fish. Aust., *1*, 1940: 167) points out that the illustration by Shaw and Nodder (Naturalist Misc., *6*, 1795: pls. 202, 203) of their problematical *Lophius monopterygius* actually represented a "beach bloated specimen" of the Australian Electric Ray later described by Duméril (Rev. Mag. Zool., (2) *4*, 1859: 279, pl. 12) as *Hypnos subnigrum;* hence, the correct name of the species is *Lophius monopterygius* Shaw and Nodder. We point out in passing that our reference of *Hypnos* to the subdivision of the family that lacks labial cartilages and in which the mouth is widely distensible is based on our own observations (Fig. 20).

when latter is closed, its length from center of cloaca more than half as great as distance from cloaca to snout; teeth with one cusp only.

Torpedo Houttuyn 1764, p. 90.

1b. Mouth narrow, not widely distensible, protractile as a short tube; upper and lower jaw cartilages bound together at each corner of mouth by a labial cartilage of two triangular elements (p. 108),[37] the cartilages rigidly articulated one with the other; integument bearing the tooth bands only loosely attached to jaw cartilages.

3a. Nostril not divided into two separate apertures by a cross bridge midway of its length; teeth extending well out onto upper and lower lips and largely

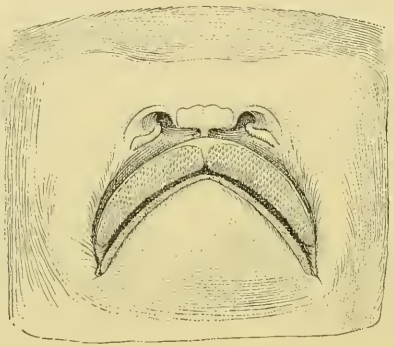

FIGURE 20. *Hypnos subnigrum*, female, about 185 mm long, from Port Jackson, New South Wales (Harv. Mus. Comp. Zool., No. 984). Nostrils and mouth, about 1.5×.

exposed when mouth is closed; lateral terminations of tooth bands not marked by deep cross furrows.

4a. Eye minute, sometimes entirely concealed by overlying integument, hence doubtless blind; sides of tail without longitudinal membranous fold, at most with a low fleshy ridge.

Benthobatis Alcock 1898, p. 126.

4b. Eyes normally developed and functional; each side of tail with a thin ribband-like longitudinal fold.

5a. Nasal curtain much broader than long.

6a. Posterior margins of pelvics not joined across base of tail in a continuous arc by a membranous connection.

Narcine Henle 1834, including *Narcinops* Whitley 1940, p. 107.[38]

37. The presence of these labial cartilages is easily detected by touch in specimens not hardened too much in preservative.
38. See p. 107, footnote 108.

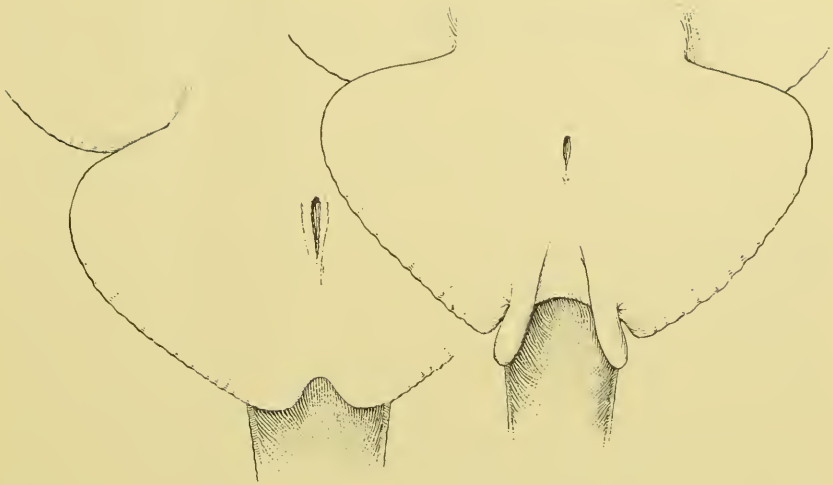

FIGURE 21. *Discopyge tschudii*. Left, Pelvic fins of female, 264 mm long, from off Argentina, Lat. 46°15′ S, Long. 65°02′ W (British Museum [Natural History]). Right, Same of male, about 400 mm long, from Argentina (U. S. Nat. Mus., No. 53439).

6b. Posterior margins of pelvics joined across base of tail by a membranous connection, either continuous or narrowly indented in the midline (Fig. 21). *Discopyge* Heckel 1845.[39]
Peru, Chile, and the western South Atlantic from southern Argentina to Rio de la Plata.

5b. Joint nasal curtain only slightly broader than long.
Heteronarce Regan 1921.[40]
Arabian Sea and Indian Ocean south to East London, about Lat. 33° S.

3b. Nostril divided into two separate apertures by a cross bridge about midway of its length; teeth entirely enclosed within the mouth when latter is closed;

39. It has long been known that females of the type species of *Discopyge* (*Torpedo tschudii* Heckel 1845) differ in a striking way from those of *Narcine* in that the pelvics are united by a membranous connection across the base of the tail. This was emphasized in the original account of the species by Heckel (in Tschudi, Fauna Peruana, Ichthyol., 1845: 32, pl. 6) and was verified subsequently by Berg (An. Mus. nac. B. Aires, *4*, 1895: 12). While the tips of the pelvics of the male project a little farther rearward than in the female, they are similarly joined across the tail in an Argentine specimen that we have examined (Fig. 21). The only previous illustration of the male (Steindachner, Zool. Jb., Suppl. *4*, 1898: pl. 21, fig. 14b) shows the membrane as narrowly interrupted in the midline.

40. *Heteronarce* is so close to *Narcine* that its generic validity is doubtful. According to its author (Regan, Ann. Mag. nat. Hist., [9] 7, 1921: 414), it differs from *Narcine* only in the greater length (relative to breadth) of its nasal curtain. Presumably, therefore, its type species (*Heteronarce garmani* Regan) has a protractile mouth with labial cartilages. And Annandale's illustration (Mem. Indian Mus., *2*, 1909: pl. 3A, fig. 3) suggests that this is also the case in *Narcine mollis* Lloyd (Rec. Indian Mus., *1*, 1907: 8), which has subsequently been referred to *Heteronarce* (Fowler, Bull. U. S. nat. Mus., 100 [13], 1941: 338).

median sectors of lips, to which the tooth bands extend, marked at either end by a deep transverse groove.

Diplobatis Bigelow and Schroeder 1948, p. 123.

Genus *Torpedo* Houttuyn 1764

Torpedo Houttuyn, Nat. Hist. Dieren, Planten en Mineral., *6*, 1764: 453; type species, generally accepted as *Raja torpedo* Linnaeus 1758. Mediterranean.

Generic Synonyms:

Narcobatus Blainville, Bull. Soc. philom. Paris, 1816: 121; type species, *Raja torpedo* Linnaeus 1758; designated by Jordan (Genera Fish., *1*, 1917: 95).[41]

Narcobatis Blainville, in Vieillot, Fauna Franç., Poiss., 1825: 43; emended spelling for *Narcobatus* Blainville 1816.

Narcacion Gill, Ann. N. Y. Lyc., *7*, 1862: 387; diagnosis, no species mentioned.[42] A revival of *Narcacion* Klein 1777.

Tetronarce Gill, Ann. N. Y. Lyc., *7*, 1862: 387; type species, *Torpedo occidentalis* Storer 1843.

Gymnotorpedo (subgenus) Fritsch, Arch. Anat. Physiol., Leipzig (1886), Physiol. Abt., 1886: 365; type species, *Torpedo occidentalis* Storer 1843, designated by Jordan (Genera Fish., *4*, 1920: 435).

Fimbriotorpedo (subgenus) Fritsch, Arch. Anat. Physiol., Leipzig (1886), Physiol. Abt., 1886: 365; type species, *Torpedo marmorata* Risso 1810. Mediterranean.

Tetranarce Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 222; Jordan, Genera Fish., *3*, 1919: 307; emended spelling for *Tetronarce* Gill 1861.

Tetronarcine Tanaka, J. Coll. Sci. Tokyo, *23*, 1910: 2; type species, *T. tokionis* Tanaka. Japan.

Eunarce (subgenus) Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 472; type species, *Torpedo narke* Risso 1810, Meditterranean, probably equals *Raja torpedo* Linnaeus 1758.

Notostrape Whitley, Rec. Aust. Mus., *18*, 1932: 372; type species, *N. macneilli* Whitley, New South Wales; probably not distinguishable from *Torpedo fairchildi* Hector (Colonial Mus. Geol. Surv. N. Z., 1872: 83, pl. 12, fig. 134). Not seen.

Generic Characters. Disc broader than long and arcuate laterally, its anterior margin either slightly convex, nearly straight, or even slightly concave along median sector; length in front of orbits not greater than distance between outer ends of spiracles or between outer edges of eyes. Snout soft to the touch. Tail with a low fold along each side; its length from center of cloaca to termination considerably less than distance from cloaca to snout; its length from tips of pelvics more than twice as great as apparent breadth of mouth. Base of first dorsal wholly or partly above bases of pelvics. Second dorsal noticeably smaller than first dorsal. Caudal subtriangular, about as large in extent below its axis as above, its axis slightly raised. Pelvics with at least their tips free from sides of tail. Eyes well developed, pigmented and functional, though small.

41. The list of species mentioned by Blainville 1816 in his original diagnosis of *Narcobatus* did not include *Raja torpedo*, but it did include *R. unimaculatus*, presumably of Risso 1810, which equals *Raja torpedo* Linnaeus 1758. The designation of the latter as type of the genus was therefore justified.

42. The earliest post-Linnaean use of *Narcacion* was by Klein (Neuer Schauplatz, *4*, 1777: 726); type species *Raja torpedo* Linnaeus 1758. But the International Commission on Zoological Nomenclature has ruled (Opin. Rend., Smithson. Publ., No. 1938, 1910: 51; Smithson. misc. Coll., *7* [3], 1925: 27) that neither Klein's generic names, nor the revivals of them by Walbaum (P. Artedi Genera Pisc. Emend. Ichthyol., 1792) are permissible. Hence, *Narcacion* must date from Gill, who seems to have been the first to define the genus subsequently.

Spiracles separated from eyes by a definite interspace, their posterior margins either smooth or with papillae. Midline of back a little posterior to level of spiracles with either a pair of conspicuous mucous pores side by side or a group of 5–9. Nostrils transverse to slightly oblique, much closer to mouth than to tip of snout, longer than space between them. Nasal curtain subquadrangular, considerably broader than long, concealing all but outer ends of nasal apertures and extending nearly or quite to upper jaw; free posterior margin of nasal curtain smooth, more or less sinuous, or with the midsector projecting somewhat. Mouth only slightly protractile, if at all, without labial cartilages and therefore widely distensible; the lateral articulations between upper and lower jaw cartilages small in area and hardly interlocking; skin at corners of mouth loose, with a well marked furrow extending rearward for some distance;[43] roof of mouth without digitate lobes anterior to the main transverse fold, the latter smooth-edged, of nearly uniform breadth throughout its length. Tooth bands not reaching to apparent corners of mouth when latter is closed, the integument bearing them rather firmly attached to the narrow jaw cartilages. Teeth with one sharp conical cusp, arranged in quincunx close together; up to about 64 series in each jaw, with 3 or 4 to 6 or 7 rows in function simultaneously. Two rostral cartilages, each a flexible unbranched vertical plate, the pair well separated next to the cranium but approximating each other and flattened dorsoventrally toward tip of snout, where they and the neighboring antorbital cartilages are interconnected by sheets of firm fibrous tissue.[44] Characters otherwise those of the family.

Size. This genus includes the largest of Atlantic Electric Rays (p. 85).

Developmental Stages. It has been known for more than a century that the inner wall of the uterus in gravid females of some species is set with vascular villi, while in that of others it bears a series of longitudinal folds only.[45] The later embryonic stages of *Torpedo* are of special interest because the anterior limits of the pectorals in some are marked by a well marked notch on either margin of the disc until the young are nearly ready for birth (Fig. 23). These notches are described and figured as persisting for a time after birth in three species.[46]

Habitat and Range. In the Atlantic the genus *Torpedo* occurs in water of only a

43. The degree to which the jaws may protrude and the width to which the mouth may gape when spread to its widest (not yet known), can be determined only from observation on living specimens when they are feeding.

44. Garman's illustrations (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 67, figs. 1, 2) show the rostral cartilages of *Torpedo marmorata* as rounded bars branched at the tips. But those on his original dissection are as described above. Also, the margin of the antorbital cartilages are not as complexly dissected as they are represented in his illustrations.

45. Davy, Philos. Trans., 1834: 547; Müller, Über den glatten Hai (1839–1840), 1842: 55. For a recent account of the uterine wall of *Torpedo torpedo* (Linnaeus) 1758, with photographs, see Ranzi (Publ. Staz. zool. Napoli, *13*, 1934: 359); also see Needham (Biochem. Morphogen., 1942: pl. 1, fig. 7).

46. Small European specimens of *Torpedo nobiliana* are so pictured by Bonaparte (Icon. Faun. Ital., *3*, 1835: pl. not numbered), by Rey (Fauna Iberica, Peces, *1*, 1928: 524, fig. 168), and by Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 120, fig. 48), as are the New Zealand *T. fairchildi* (as *Torpedo fusca* by Parker, Trans. Proc. N. Z. Inst., *16*, 1884: 283, pl. 22, fig. 1) and *T. nobiliana* of the western Atlantic by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 61, figs. 4–5). Kaempfer's early illustrations (Amoenitatum Exoticorum, 1712: pl. to face p. 511, figs. A, B) of *T. sinus-persicus* Olfers 1831 of the Persian Gulf, Red Sea, and Indian Ocean, though crude, also show the notched pectorals.

few feet deep down to 50–60 fathoms, but its depth range is known to reach at least 130 and perhaps 300 fathoms in the Great Australian Bight.[47]

The geographical range of the genus is known to extend from northern Scotland[48] and the North Sea (inward as a stray to the Skagerrak and Kattegat)[49] to tropical West Africa (Senegal) in the eastern Atlantic, including the Mediterranean; from Nova Scotia to Cuba in the west. *Torpedo* is also known from: northern Argentina; southern British Columbia to southern California on the Pacific Coast of North America, and perhaps from Chile;[50] Japan; southeastern and southern Australia and New Zealand; the Indian Ocean region in general, including the Persian Gulf and Red Sea, southward to Madagascar, Natal, and the Cape of Good Hope.

Species. One species, *Torpedo mackayana* Metzelaar 1919,[51] that falls within the limits of the genus in other respects is set apart from all of its generic relations—for that matter, from all other members of the suborder—by the presence of small papillae along the margins of its pectorals, described as "partly spinous." Indeed, it is so aberrant in this respect that a separate genus may prove requisite for it when it is better known. The species that remain, after the subtraction of *T. mackayana*, have been divided by some authors into two genera or subgenera, or even into three, depending on whether the margins of the spiracles are smooth or are rimmed with short tentacular structures or papillae.[52] But it is not possible to draw any sharp line even between those species in which the spiracles are the most evidently papillate and those in which they are perfectly smooth. The gap between them is bridged by *Torpedo fuscomaculata* of the Indian Ocean, in which the spiracular papillae are conspicuous in young specimens but decrease in relative size with growth, and by *T. torpedo* (Linnaeus) 1758, in which the papillae are represented in the young by only low knobs that dwindle with growth until they are probably wholly obliterated by maturity in some specimens.

47. McCulloch (Biol. Result. Fish. F. I. S. 'Endeavour', *5* [4], 1926: 159) reports *Torpedo fairchildi* from trawl hauls made at 100–220 fathoms in Bass Strait, at 80–120 fathoms and at 130–320 fathoms in the Great Australian Bight.
48. Sim (Vert. Fauna Dee, 1903: 274) reports (seemingly on good evidence) the capture of several *Torpedo nobiliana* from Wick Bay and its offing, and from Moray Firth for the years 1890–1894, one specimen being 3 feet 9 inches long.
49. Lübbert and Ehrenbaum, Handb. Seefisch. Nordeuropas, *2*, 1936: 317; Andersson, Fiskar och Fisk i Norden, 1942: 275.
50. It is not clear from Guichenot's (Fauna Chilensis, *2*, 1848: 368) brief account whether his *Torpedo chilensis* actually belonged to *Torpedo* or to *Discopyge*.
51. Trop. Atlant. Visschen, 1919: 197, fig. 57, Senegal; known from a single specimen only.
52. The genus *Tetronarce* was proposed by Gill (Ann. N. Y. Lyc., *7*, 1862: 387) for species with spiracles having smooth borders, those with "dentated" spiracles being referred by him to *Narcacion*, which is equivalent to *Torpedo*. Fritsch (Arch. Anat. Physiol., Leipzig [1886], Physiol. Abt., 1886: 355) divided *Torpedo* into two new subgenera, *Gymnotorpedo* for species with smooth spiracles, *Fimbriotorpedo* for those with papillate ones. Whitley (Rec. Aust. Mus., *18*, 1932: 327) has instituted a new genus *Notostrape* for a smooth-spiracled species (*Notostrape macneilli* Whitley 1932, Australia, apparently equals *Torpedo fairchildi* Hutton 1872, New Zealand) without mentioning any differences to set it apart from the older subdivisions (generic or subgeneric) that had been proposed previously for species belonging to this category. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 342) used the old names *Torpedo* for the smooth-spiracled category and *Tetronarce* for the papillate, having suggested three subgenera earlier (Proc. Acad. nat. Sci. Philad., *62*, 1910: 472), *Narcobatus* with papillate spiracles, *Tetronarce* with smooth, and a new subgenus *Eunarce* with "spiracle fringes as rudimentary papillae." And Fraser-Brunner (Ann. Mag. nat. Hist., [2] *2*, 1949: 943) recognizes two subgenera, *Torpedo* for the species with papillate spiracles, *Tetronarce* for those with smooth ones.

A character more useful as the primary alternative for specific identification is whether the rear end of the first dorsal base is considerably posterior to the rear ends of the pelvic fin bases or is level with or even anterior to the latter.[53]

All of the four species of *Torpedo* known from the Atlantic (*T. torpedo* Linnaeus 1758; *T. marmorata* Risso 1810; *T. nobiliana* Bonaparte 1835; and *T. puelcha* Lahille 1928) fall in the group in which the first dorsal base extends rearward well beyond the pelvic bases.[54] Among these, *T. marmorata* of the eastern Atlantic and Mediterranean is recognizable by the prominent papillae that surround its spiracles; *T. torpedo*, also of the eastern Atlantic and Mediterranean, has a conspicuous color pattern with a few large blue-centered ocelli;[55] *T. nobiliana*, from both the eastern and western North Atlantic, is recognizable by its plain coloration and smooth spiracles and by an interspace between its second dorsal and caudal that is little longer than the base of the first dorsal; *T. puelcha* from Argentina is identifiable by the long interspace between its second dorsal and caudal fins (Key, p. 94), also by plain coloration and smooth spiracles.

Two more Torpedoes are known in which the first dorsal extends far rearward; *sinus-persicus* Olfers 1831, Indian Ocean, with papillate spiracles, and a smooth-spiracled form of problematic identity, from Agulhas Bank (South Africa).[56]

The subdivision of the genus in which the base of the first dorsal terminates at a level with the rear ends of the pelvic fin bases, or anterior thereto, known only from the western Pacific and Indian oceans so far, includes one group of two species (*T. fairchildi* Hutton 1872 and *T. macneilli* Whitley 1932) in which the edges of the spiracles are smooth and another group of named forms[57] in which the spiracles bear more or less obvious papillae. All of these have been united recently with *T. marmorata* of the eastern Atlantic and Mediterranean.[58] But they all differ from *T. marmorata* in the position of the first dorsal, which has the rear end of its base at least as far anterior as the rear ends of the bases of the pelvics (well posterior to the rear ends of the pelvic bases in *marmorata*). They are regarded here as representing two species, *T. panthera* Olfers 1831 and *T. fuscomaculata* Peters 1855.[59]

53. The number of columns in each electric organ was proposed as the primary specific character by DuBois Reymond (Arch. Anat. Physiol., Leipzig [1882], Physiol. Abt., 1882: 400; Rep. Brit. Ass., 1882: 542), for it differs in different Torpedoes and increases but little from birth onward.

54. The illustration of *T. marmorata* by Rey (Fauna Iberica, Peces, *1*, 1928: pl. 9, fig. 2) shows the rear end of the base of the first dorsal about even with the rear ends of the bases of the pelvics. Actually it is considerably posterior thereto in the specimens we have examined, and it has been so described repeatedly.

55. For identification of occasional specimens of *T. torpedo* that may be plain-colored, see Key to Species, alternatives 8b (p. 94) and 11b (p. 95).

56. Reported first by Thompson (Mar. biol. Rep. Cape Town, 2, 1914: 159) as *Torpedo hebetans* and subsequently by Barnard (Ann. S. Afr. Mus., *21* [1], 1925: 89) as *T. nobiliana*.

57. *Torpedo panthera* Olfers 1831; *T. fuscomaculata* Peters 1855; *T. polleni* (Bleeker) 1866; *T. suessi* Steindachner 1898; probably also *T. zugmayeri* Engelhardt 1912.

58. By Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 343). The *Raja maculata* and *R. bicolor* of Shaw (Gen. Zool., *5*, 1804: 316) from India, based on Russell's illustrations (Fish. Coromandel, *1*, 1803: pls. 1, 2) of his "Temeree" and of his "Nalla Temeree," are also listed by Fowler as synonyms of *Torpedo marmorata*. But he refers the first of these to *Narcine* on another page (Bull. U. S. nat. Mus., 100 [*13*], 1941: 333), no doubt correctly; Shaw's *Raja bicolor* was evidently a *Narcine* also.

59. We follow Fraser-Brunner (Ann. Mag. nat. Hist., [12] *2*, 1949: 943).

Key to Species[60]

1a. Margins of rear parts of pectorals with two rows of small papillae, partly spinous.
mackayana Metzelaar 1919.
Tropical West Africa.

1b. Margins of rear parts of pectorals without spinous papillae, the skin naked there, as elsewhere.

2a. Rear end of base of first dorsal considerably posterior to rear ends of pelvic fin bases.

3a. Dorsal surface of disc with five (occasionally one, three, or seven) large and conspicuous blue-centered and pale-ringed ocelli, symmetrically arranged. *torpedo* (Linnaeus) 1758.
Eastern Atlantic and Mediterranean.

3b. Dorsal surface of disc without conspicuous ocelli though sometimes otherwise blotched or spotted.

4a. Margins of spiracles smooth.

5a. Disc about as broad as long. *tokionis* (Tanaka) 1908.
Japan.

5b. Disc appreciably shorter (less than 80 %) than its breadth.

6a. Height of caudal fin not greater than distance from its own upper origin to origin of first dorsal.

7a. Interspace between second dorsal and caudal little longer than base of first dorsal.

8a. Caudal, from upper origin to midpoint of rear margin, nearly or quite as long as distance from its own origin to origin of first dorsal.
nobiliana Bonaparte 1835, p. 96.

8b. Caudal, from upper origin to midpoint of rear margin, only about as long as distance from its own origin to rear end of base of first dorsal.
torpedo (Linnaeus) 1758.
Eastern Atlantic, Mediterranean.[61]

7b. Interspace between second dorsal and caudal about 1.5 times as long as base of first dorsal.
puelcha Lahille 1928.
Argentina.[62]

6b. Caudal higher than distance from its own upper origin to origin of first dorsal by an amount about equal to length of base of first dorsal.

9a. Distance between inner ends of nostrils about half as

60. Based in part on Key by Fraser-Brunner (Ann. Mag. nat. Hist., [12] *2*, 1949: 944) to species with papillate spiracles.
61. Occasional adult specimens may be plain-colored and the spiracular knobs may be visible no longer.
62. For full account with measurements and illustrations, see Lahille (An. Mus. nac. B. Aires, *34*, 1928: 332, pl. 5).

long as distance from tip of snout to mouth; head anterior to spiracles about 2.5 times as long as distance between inner ends of spiracles.

macneilli (Whitley) 1932.
Southern Australia.[63]

9b. Distance between inner ends of nostrils only about $^1/_3$ as long as distance from tip of snout to mouth; head anterior to spiracles only about 1.8 times as long as distance between inner ends of spiracles.

californica Ayres 1855.
Pacific Coast of North America, southern British Columbia to southern California.

4b. Margins of spiracles with a row of papillae or knobs.

10a. Margin of spiracle with seven papillae.

11a. Spiracular papillae so long that their tips come close together in center of spiracular opening; distance from midpoint of posterior margin of caudal to origin of first dorsal only about half as long as distance from origin of first dorsal to tip of snout; nuchal region with a group of 5–7, or more, conspicuous mucous pores irregularly arranged.[64]

marmorata Risso 1810.
Eastern Atlantic and Mediterranean.

11b. Spiracular papillae low, inconspicuous, knob-like; distance from midpoint of posterior margin of caudal to origin of first dorsal about $^2/_3$ as long as distance from origin of first dorsal to tip of snout; nuchal region with only one pair of conspicuous mucous pores, side by side.

torpedo (Linnaeus) 1758.
Eastern Atlantic and Mediterranean.[65]

10b. Margin of spiracle with 9 or 10 papillae.

sinus-persicus Olfers 1831.
Persian Gulf, Indian Ocean south to Natal, Red Sea.[66]

63. *Torpedo macneilli* from New Zealand has been united with *T. fairchildi* Hutton 1872 by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 345). But the rear end of the base of its first dorsal is considerably posterior to the rear ends of the pelvic fin bases, not in a line with the latter, as appears to be the case in the New Zealand *T. fairchildi* (Hutton, Colonial Mus. Geol. Surv. N. Z., 1872: 83, pl. 12, fig. 134). For a detailed account of the Australian *T. macneilli*, see McCulloch (Rec. Aust. Mus., *12*, 1919: 171, pl. 25, as *Torpedo fairchildi*).
64. In all of the other species of the genus that we have examined there is only a pair of these pores, side by side, in the nuchal region.
65. Occasional specimens lack the ocellar spots that are usually the most conspicuous feature of this species.
66. This characterization of *T. sinus-persicus* follows Fraser-Brunner (Ann. Mag. nat. Hist., [*12*] *2*, 1949: 943); it includes *T. suessi* Steindachner 1898, Red Sea.

2b. Rear end of base of first dorsal level with rear ends of pelvic fin bases, or anterior to them.

12a. Edges of spiracles smooth. *fairchildi* Hutton 1872.
New Zealand.[67]

12b. Edges of spiracles with a row of papillae or knobs.

13a. Eyes about midway between anterior margin of snout and spiracles, or very little nearer the latter; interspace between first and second dorsals only as long as distance between second dorsal and caudal. *panthera* Olfers 1831.
Red Sea; also reported from western Indian Ocean from Gulf of Oman to Reunion, Mauritius, Madagascar, Mozambique Channel, and the Natal Coast,[68] but perhaps not correctly.

13b. Eyes much nearer to spiracles than to anterior margin of snout; interspace between first and second dorsals longer than distance between second dorsal and caudal. *fuscomaculata* Peters 1855.
Zanzibar, Seychelles, Mauritius, Madagascar, and Mozambique.[69]

Torpedo nobiliana Bonaparte 1835

Electric Ray, Torpedo, Numbfish, Crampfish

Figures 22, 23

Study Material. Male, 835 mm long, taken 12–15 miles off Plymouth, Mass., in about 30 fathoms; two females, one about 1065 mm long from Provincetown, another 720 mm long from Woods Hole; four specimens, males and females, 800–1,245 mm long, from 50–67 fathoms, 60–90 miles southwest of Gay Head, Marthas Vineyard Island, Mass.; jaws of a large specimen, and an embryo about 16 cm long from Woods Hole; all in the Harvard Museum of Comparative Zoology. Also a male, 655 mm long, with large claspers, from the North Sea (loaned by British Museum [Natural History]).

Distinctive Characters. The broad subcircular disc, short snout anterior to the eyes, perfectly smooth skin, short thick tail, two well developed dorsal fins, and broad caudal fin are enough to mark *T. nobiliana* off at a glance from all other batoids of the western

67. See p. 95, footnote 63.

68. The name *panthera* was proposed originally (Olfers, Die Gattung Torpedo, 1831: 15, 16) as a color variety of *T. marmorata*, and Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 343) has relegated it to the synonymy of that species. But Rüppel's illustration (Neue Wirbelt. Abyssinia, Fische, 1835: pl. 19, fig. 1A) of what seems to be the same Red Sea form represents it as differing from *marmorata* in that the first dorsal fin is wholly anterior to the rear ends of the bases of the pelvics. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 307) so describes it for a specimen in the Harvard Museum of Comparative Zoology that we have re-examined. *T. polleni* Bleeker 1866 appears to be a synonym of *T. panthera*, as does *T. zugmayeri* Engelhardt 1912, so far as the published account (Zool. Anz., *39*, 1912: 617) of it goes, though the latter fails to include any information as to the position of the first dorsal relative to the bases of the pelvics. The specimen described by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 309) as *Narcacion sinus-persici* (Olfers) 1831, on re-examination, also proves to be referable to *panthera*.

69. Characterization and range according to Fraser-Brunner (Ann. Mag. nat. Hist., [12] *2*, 1949: 945).

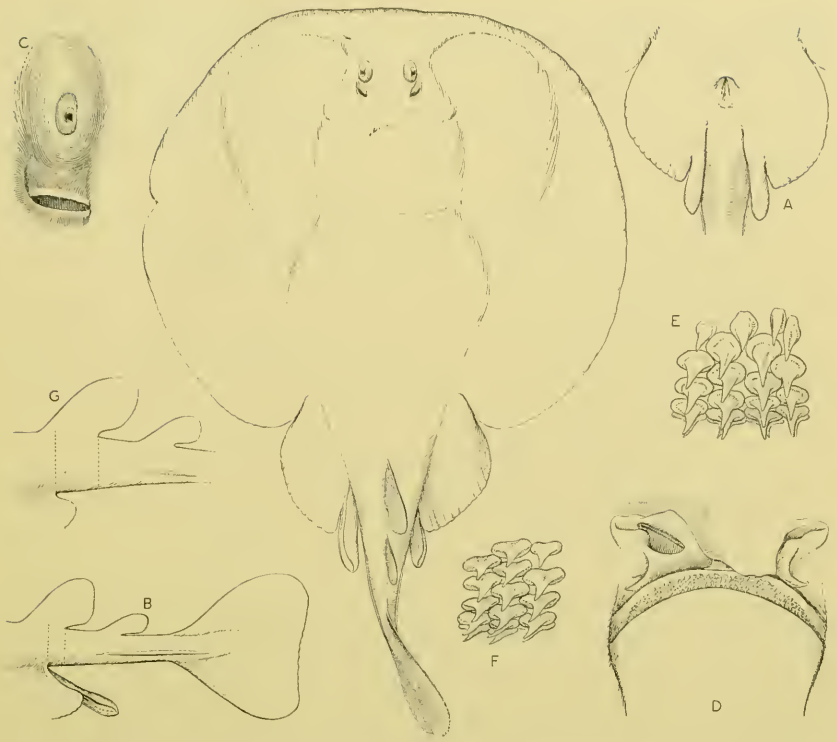

FIGURE 22. *Torpedo nobiliana*, male, 835 mm long, from off Plymouth, Massachusetts (Harv. Mus. Comp. Zool., No. 36040). *A* Pelvics of same. *B* Lateral view of tail of same. *C* Eye and spiracle of same, about 1.7×. *D* Nostrils and mouth of same, about 0.7×. *E* Upper teeth from center of jaw of same, about 4.9×. *F* Upper teeth near right-hand corner of mouth of same, about 5×. *G* Side view of tail of female, about 1,065 mm long, from Provincetown, Mass. (Harv. Mus. Comp. Zool., No. 653).

Atlantic except for the local representatives of the genera *Benthobatis*, *Narcine*, and *Diplobatis*, from which it is easily distinguishable by the wide distensibility of its mouth (gape not limited at corners by labial cartilages) and by the rather firm attachment to the upper and lower jaw cartilages of the integument that bears the tooth bands.

Further distinctions, perhaps more convenient as field marks, that set it apart from *Benthobatis* are its well developed and functional eyes, relatively much shorter snout, and wider disc. Obvious features that differentiate it from *Narcine brasiliensis* are a disc that is considerably wider than long, the anterior margin of which is nearly straight or even slightly emarginate rather than convexly rounded, and a first dorsal fin that considerably overlaps the bases of the pelvics. The fact that at least the tips of

the margins of its pelvics are free from the sides of the tail separates it (and its Argentine representative *T. puelcha* Lahille 1928) from *Discopyge*, the western Atlantic range of which is confined in any case to midlatitudes in the southern hemisphere.

Description. Proportional dimensions in per cent of total length. Female, 720 mm long, from Buzzards Bay, Massachusetts (Harv. Mus. Comp. Zool., No. 36621). Male, 835 mm long, from off Plymouth, Massachusetts (Harv. Mus. Comp. Zool., No. 36040).

Disc: extreme breadth 66.5, 65.0; length 56,0, 56.0.
Snout length: in front of orbits 7.1, 7.5; in front of mouth 9.3, 9.1.
Orbits: horizontal diameter 2.9, 3.0; distance between 3.9, 3.8.
Spiracles: length 2.8, 2.6; distance between 4.9, 5.4.
Mouth: breadth 6.7, 6.4.
Exposed nostrils: distance between inner ends 4.3, 4.4.
Gill openings: lengths, 1st 2.5, 2.0; 3rd 3.0, 2.4; 5th 1.9, 1.8; distance between inner ends, 1st 15.7, 18.0; 5th 14.6, 15.1.
First dorsal fin: vertical height 6.0, 7.2; length of base 5.8, 6.2.
Second dorsal fin: vertical height 3.1, 4.0; length of base 3.8, 3.5.
Caudal fin: upper anterior margin 17.6, 18.3.
Distance: from tip of snout to center of cloaca 58.3, 57.4; from center of cloaca to tip of tail 41.7, 42.6.
Interspace between: 1st and 2nd dorsals 3.9, 4.0; 2nd dorsal and caudal 6.8, 6.6.

Disc about 1.2 times as broad as long, its edge fleshy and thick in front but thinning progressively rearward to posterior parts of pectorals, where it is exceedingly thin; the median sector of its anterior contour nearly straight, or even slightly emarginate there in some specimens; its outer margins broadly and evenly rounded, with the embryonic pectoral notches persisting for a short time after birth in some European specimens, hence probably in American examples also.[70] Axis of greatest breadth about 55–60 % of distance rearward from snout toward axils of pectorals. Tail from center of cloaca about 67–74 % as long as distance from cloaca to snout; noticeably stout anteriorly, about twice as broad as deep at rear bases of pelvics, tapering thence rearward to caudal; moderately rounded below as well as above; each side of tail a little below the midlevel, with a low cutaneous fold extending from about opposite origin of second dorsal rearward for a short distance beyond origin of caudal.

Skin wholly naked above as well as below. Nuchal region with a pair of conspicuous mucous pores side by side.

Snout in front of eyes about as long as distance between outer margins of eyes;

70. This was the case in specimens of about 244 mm (9.66 in.) and 281 mm (11.06 in.) long, figured respectively by Bonaparte (Icon. Faun. Ital., *3*, 1835: pl. not numbered) and Rey (Fauna Iberica, Peces, *1*, 1928: 524, fig. 168). An Irish specimen also has been described and pictured by McCoy (Ann. Mag. nat. Hist., *6*, 1841: 407, 408, as *T. emarginata*) as having notches still visible at a length of 2 feet 8 inches. But such notches have not been reported for any American specimen subsequent to birth. We should point out that the indentation in the left-hand margin of the disc of the specimen pictured in Fig. 22 is far posterior to the anterior limits of the pectoral, and hence it is the result of deformation or injury rather than the persistence of one of the embryonic pectoral notches.

its length in front of mouth about twice as great as distance between outer ends of exposed nostrils. Eyes noticeably small but fully developed; horizontal diameter about $^1/_3$–$^1/_2$ as long as distance between orbits, or a little less. Spiracles moderately oblique, sloping rearward inwardly, about as long as orbit and about 1.5 times as long as horizontal diameter of eye; posterior to eyes by a distance a little longer than eye; their margins perfectly smooth. Second to fourth gill openings (about equal in length) a little more than $^1/_3$ as long as breadth of mouth; first about 85 % and fifth about 75 % as long as third or fourth (the longest); distance between inner ends of fifth gill openings about 2.0–2.3 times as great as breadth of mouth, and 82–92 % as great as distance between inner ends of openings of first pair. Nostrils moderately oblique, close to mouth but entirely separate from it; distance between their inner ends (concealed by the nasal curtain) about half as great as distance between orbits and about $^1/_3$ as great as breadth of mouth; joint nasal curtain subrectangular, about three times as broad as long, roofing over the inner half to third of each nasal aperture; its free rear margin somewhat sinuous, sometimes with a shallow median notch; posterior margin of nostril with two semilunar expansions, the free margin of the outer (anterior) directed toward the nasal aperture, that of the inner (posterior) away from it and toward the mouth. Mouth moderately arched, its apparent breadth when closed about 1.7 times as great as distance between orbits, the furrow from each corner extending rearward for a distance slightly more than $^1/_3$ as great as breadth of mouth when mouth is closed, perhaps entirely obliterated when mouth is open.

Teeth increasing in number of series with growth from $^{38}_{38}$ at a length of 655 mm (North Sea specimen) to $^{48}_{46}$ at 835 mm and to $^{66}_{61}$ at 1,040 mm (American specimens); cusps sharp or slightly blunted, about as long as breadth of bases in both sexes, directed into mouth, those on each side of jaws curving slightly toward corner of mouth; up to seven rows in function simultaneously in medium and large specimens, these succeeded by several additional replacement rows that are already of the final shape though still soft and covered over by folds of skin from roof and floor of mouth.

First dorsal about as high vertically as long; subtriangular with rounded corners; anterior margin convex toward apex, distal margin nearly straight, free lower posterior margin about half as long as base; its length along anterior margin about equal to distance from posterior margin of spiracle to tip of snout; its origin anterior to axils of pelvics by a distance $^1/_3$–$^1/_4$ as long as its base in female, about $^2/_3$ as long as its base in mature male. Second dorsal only about $^1/_2$–$^2/_3$ as large as first dorsal in linear dimensions and relatively lower, its anterior margin more sloping, its lower posterior free margin relatively longer. Interspace between first and second dorsals about $^3/_4$ as long as base of first dorsal. Interspace between second dorsal and caudal about as long as base of first dorsal or a little longer. Caudal approximately an equilateral triangle; its upper and lower margins weakly convex, its posterior margin nearly vertical and weakly emarginate; corners broadly rounded; its axis slightly raised; its length from origin to midpoint of rear margin about as great as distance from origin of first dorsal to rear tip of second dorsal; its upper origin about opposite its lower origin. Pelvics with

broadly convex outer margins[71] but with abruptly rounded or subangular posterior corners, their inner posterior margins free from sides of tail for a distance about 1/4 as great as distance from origin of pelvic to its tip; their length (origin to tip) about as great as distance from origin of first dorsal to origin of caudal.

Each electric organ may have as many as 1,000–1,100 columns.

Color. Dark chocolate to purplish brown above, or even nearly black, either uniform or with a few obscure darker spots. Generally white below, but with edges of disc and pelvics of same hue as upper surface; tail with irregular dark margins.

Size. At birth the length of *Torpedo nobiliana* is probably between 200 and 250 mm, for the embryonic pectoral notches still showed on Mediterranean specimens of 244 and 281 mm (see p. 91) and the umbilical scar was still evident on an Algerian specimen 261 mm long.[72] The smallest free-living American specimen recorded so far had already grown to a length of 610 mm. It is not known at just what length this species matures sexually, but it is likely that all specimens that have grown to two feet or more are close to sexual maturity, if they have not already reached it. One, netted off Woods Hole, Massachusetts, was 56 3/4 inches long,[73] and the largest for which the dimensions are definitely recorded, taken at Cape Lookout, North Carolina in February, measured 60 1/2 inches in length by 41 inches in breadth. But larger ones are caught in the Woods Hole region,[74] while Mediterranean specimens 63 inches (1.6 m)[75] and 5 feet 11 inches (1.8 m)[76] long have been reported.

The average weight of specimens taken at Woods Hole is reported to be about 30 pounds, and most of those taken anywhere on the coast weigh less than 75 pounds. But the relationship between length and weight varies considerably, depending on the fatness of the fish. This is illustrated by the fact that a specimen only 47.5 inches long from Chesapeake Bay, examined by us, weighed about 100 pounds, whereas one of 48.5 inches from Cape Cod Bay weighed 81 pounds,[77] and another of 52 inches from the southern part of Georges Bank weighed only 78 pounds. The North Carolina specimen mentioned in the preceding paragraph (60.5 in. long) weighed 125 pounds; one of about 134 pounds (61 kg) has been reported from Cape Lookout, and many years ago another of 144 pounds was brought from Nantucket to the station of the U. S. Bureau of Fisheries at Woods Hole, Massachusetts.[78] The heaviest ones taken

71. The pelvics of the specimen pictured in Fig. 22 show an interesting divergence on the two sides of the body, the outer contour being the more evenly rounded on the right-hand fin.
72. The original account of this specimen (Guichenot, Explor. Alger., Poiss., 5, 1850: 131, pl. 8, as *Torpedo nigra*) did not mention its length, which was given subsequently by Duméril (Hist. Nat. Poiss., 1, 1865: 512).
73. Reported to us by F. E. Firth, U. S. Bureau of Fisheries.
74. Captain Donald Campbell, a fisherman of many year's experience, informs us that he has seen them up to five or six feet across near Woods Hole, Massachusetts.
75. Duméril, Hist. Nat. Poiss., 1, 1865: 511, by ref. to Bonaparte (probably Obs. sur la torpille, Actes 1 Congr. Pise, 1840: 18; not seen).
76. Gibert, Bull. Inst. Catalon. Hist. nat., 1911: 102; Rey, Fauna Iberica, Peces, 1, 1928: 526.
77. Reported by Dorothy Snyder.
78. Recorded weights of a few British specimens of different sizes are as follows: 13 pounds at 28 inches, 25 pounds at 33 inches, 42 pounds at about 40 inches, 82 pounds at 46 inches, and 110 pounds for one between 60 and 64 inches long, the latter the largest that had been reported from British waters up to 1925 (Jenkins, Fish. Brit. Isles, 1925: 329).

near Provincetown, at the tip of Cape Cod, Massachusetts, were estimated long ago by a fisherman of keen observation as reaching 170 to 200 pounds.[79]

Developmental Stages. The number of young has not been recorded for any American specimen.[80] The disc of an embryo about 140 mm long, taken from a female that was landed at Woods Hole, Massachusetts, is deeply notched on both sides about opposite the mouth, marking the anterior limits of the pectorals. At this stage, still

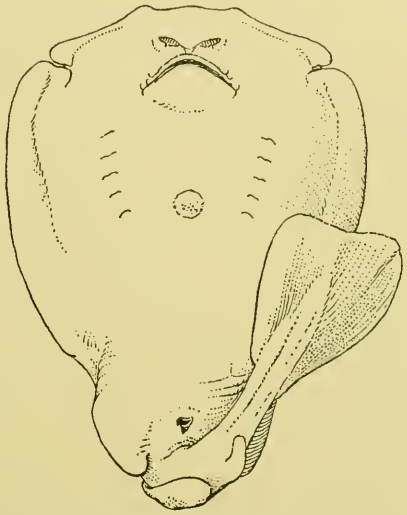

FIGURE 23. *Torpedo nobiliana*, embryo, 159 mm long, from Woods Hole, Mass. (Harv. Mus. Comp. Zool., No. 1016), about 0.9 natural size.

considerably previous to birth, the posterior margins of the pectorals merge insensibly with the sides of the trunk, the pelvics are still small, and the curtain-like expansion of the anterior margins of the nostrils has not developed and hence the entire lengths of the nasal openings are freely exposed. But the caudal is already of approximately adult form, the relative sizes of the dorsals are already established, the eyes and spiracles are approximately of adult proportions, and the older series of teeth already have cusps. The embryo lies in the uterus with the tail bent forward ventrally and the caudal fin flat against the left-hand pectoral (Fig. 23).

79. This estimate by Captain N. E. Atwood, first quoted by Storer (Amer. J. Sci., *45*, 1843: 167), has been the basis for many subsequent statements that this *Torpedo* reaches a weight of 200 pounds.

80. A European female has been described as having 60 embryos (Duméril, Hist. Nat. Poiss., *1*, 1865: 512, by ref. to Bonaparte [probably Obs. sur la torpille, Actes 1 Congr. Pise, 1840: 18; not seen]). However, this number is much larger than that reported for other Torpedoes.

Habits. Practically nothing is known of the way of life of *T. nobiliana*. Probably it spends most of its time on the bottom partially buried in sand or mud, awaiting whatever prey may come within its reach. But the rather frequent captures of Torpedoes in pound nets near Woods Hole, Massachusetts, and the netting of at least one in a seine, shows that they move about more or less actively and may swim up from the sea floor, probably in pursuit of small fish.

A few of the specimens that have been examined at Woods Hole have contained fish: a summer flounder (*Paralichthys dentatus*) about $14^1/_2$ inches long (37 cm) was taken from one. A two-pound eel and a one-pound flounder were found in one from British waters, a salmon weighing between four and five pounds was found in another, a red mullet (*Mullus surmuletus*) and a plaice (*Pleuronectes platessa*) were recovered in a third, and the remains of a small Spotted Dogfish (genus *Scyliorhinus*) were found hanging from the mouth of still another British specimen when caught.[81] Evidently the wide distensibility of the jaws enables it to swallow fishes much larger than might seem possible from the apparent breadth of its mouth when closed, and its sharp recurved teeth serve not only to prevent its victim from escaping but as an aid in swallowing. It is believed generally that it stuns the fishes on which it preys by means of its electric discharges. Otherwise it is difficult to conceive how a fish as sluggish as this could capture other active fishes. However, the actual process has not been observed. Also, it has been reported repeatedly as caught by hook and line on dead bait of one kind or another.

Its scarcity on the grounds where otter trawlers normally operate, though within its known range, suggests that it is most apt to be found on flat sandy or muddy bottom, as in the case of its representative in British waters.[82]

Of its breeding habits in American waters we know only that a female containing one embryo was taken near New York in June, that another gravid female was captured at Woods Hole in summer,[83] and that the eggs of this species are said to be nearly ripe late in June,[84] which suggests that the period of gestation is nearly a year. It seems that the young are born offshore, for the smallest individual recorded from American inshore waters, a New Jersey specimen, was 610 mm long.[85]

The statement has long been current that the shock from a large Torpedo of this species in rested condition may be strong enough to throw a grown man to the ground,[86] and it is stated also that a shock may be received through the wet handle of a gaff-hook or harpoon. Antedating the scientific naming of the New England Torpedo is the anecdote[87] of a dog, who, being in the habit of wading in shoal water on a Cape

81. Day, Fish. Gt. Brit., *2*, 1880–1884: 331.
82. Day, Fish. Gt. Brit., *2*, 1880–1884: 331.
83. Our Study Material includes one embryo from this female, but no record was kept of the total number that she contained.
84. Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739.
85. Fowler, Proc. Acad. nat. Sci. Philad., *74*, 1922: 3.
86. It seems that most of the published statements to this effect for *Torpedo nobiliana* in American waters lead back to Atwood's report that he had "received many powerful shocks" from Torpedoes taken near Provincetown, Massachusetts, "which have thrown me upon the ground as quick as if I had been knocked down with an ax" (see Storer, Amer. J. Sci., *45*, 1843: 167).
87. Storer, Rep. Fish. Rept. Birds Mass., 1839: 201.

Cod beach to catch flounders, was so shocked by a Torpedo that it ran away howling and could never be persuaded to go fishing again.

However, shocks of a strength even approaching what is suggested by such reports are to be expected only from Torpedoes of the largest size, and then only if they are in a rested condition while in the water or soon after capture. But it is likely that the voltages of 170–220 that have been recorded recently for *T. nobiliana* after several weeks in a live well are considerably lower than the voltage that these same specimens might have delivered had they been at liberty and had they fed recently.[88] A slight benumbing or tingling sensation is the most that we have felt from medium-sized specimens lying on the dock at Woods Hole.

The great majority of American records for *T. nobiliana* are of specimens that have been either seined or taken in pound nets in a few feet of water or stranded on the beach. It has even been taken in sounds behind barrier beaches, as near Manteo on Roanoke Island, North Carolina, and on the coast of New Jersey. But the number of such captures has been so small as to make it likely that they represent merely the fringe of a population that centers farther out in depths of perhaps 10–40 fathoms, as is said to be true of it in British waters.[89] Our Study Material includes one trawled in Massachusetts Bay at 30 fathoms and another taken by Captain Jared Vincent (with 12 others, all large) in February 1949 about 60 miles off Marthas Vineyard in 50 fathoms. Another large specimen, about four feet wide, was taken in January 1949[90] with three smaller ones in 50–60 fathoms in the Hudson Gorge off New York. In June 1931[91] a large one was netted in 17 fathoms some 30 miles from the nearest land off Woods Hole, Massachusetts. And specimens have been taken on La Have Bank and on the southwest part of Georges Bank in water at least 30–50 fathoms deep.

Except for a single specimen taken at Cape Lookout, North Carolina, in February, the records of its capture close inshore have been between spring and November. It appears that the few individuals that do stray close inshore to the northward during the warmer half of the year may do so as early in the season at one point along the coast as at another. October and November have been described as the months of most frequent occurrence for them off southern Massachusetts and along Cape Cod. The paucity of records for it south of Cape Lookout suggests that it cannot survive subtropical temperatures for any length of time.

Numerical Abundance. The coastwise sector from the tip of Cape Cod to the offing of Rhode Island is the only one in the western Atlantic where reports of its presence rest on more than an occasional capture, and even there the numbers taken are small as compared with some of the Skates (genus *Raja*). At most, 60–80 are said to have been taken yearly along Cape Cod when they have been most plentiful there (p. 104), and perhaps 15–20 during the spring on the south shore of Marthas Vineyard. As many as 12 have been taken in one lift of a fish trap near Woods Hole and in Vineyard

88. See Coates and Cox (Zoologica N. Y., *27*, 1942: 28) for voltages, current, and power delivered by adult *T. nobiliana* with various resistances.

89. Day, Fish. Gt. Brit., *2*, 1880–1884: 331.

90. Reported to us by Captain Frank Janssen.

91. Personal communication from F. E. Firth, U. S. Bureau of Fisheries.

Sound, but more commonly only 1–4, if any, are captured.[92] All reports from farther west and south have been based on only one or two individuals there, at long intervals. Numbers such as these are not large enough to suggest the presence of a self-supporting local stock. For this reason we believe that the center of population for *T. nobiliana* lies farther out on the continental shelf (p. 103).

It has been known for a long time that Torpedoes are encountered much more frequently in some years than in others along the northeastern seaboard of the United States.[93] Thus, it is said that Torpedoes were unusually abundant near Provincetown during the period from 1819 through the succeeding four or five years, with 60–80 taken there yearly. But according to reports, the catch for Cape Cod during the ten-year period preceding 1845 did not exceed 30 in all.[94] The next incursion of Torpedoes near Provincetown appears to have taken place in 1845, with a dozen or so reported. Any fluctuations that may have taken place from year to year thereafter seem to have attracted no attention until the summer of 1896, when several were collected along the coast of Maine. Within a short period during the summer of 1941, several were taken at Cape Lookout, North Carolina, where only three specimens had been reported in scientific literature previously (p. 105). It is not known whether these fluctuations are reflections of corresponding variations in the strength of the offshore population or are merely an indication of the chance distribution of individuals that come close inshore from year to year.

Relation to Man. At present the Torpedoes that are taken along the eastern seaboard of the United States are of no commercial value. It is rumored that local fishermen at an earlier date considered their oil a useful remedy for muscular cramps when applied externally and for cramps of the stomach when taken internally.[95] We are informed[96] that small amounts were also used for lubricating farm machinery. The few specimens that are landed at Woods Hole attract the attention of workers at the Marine Biological Laboratory because of the electric organs and their discharges.

Range. Both sides of the North Atlantic, from northern Scotland to the Mediterranean, Azores, Madeira, and tropical West Africa[97] in the east; from southern Nova Scotia, La Have Bank, mouth of the Bay of Fundy and Georges Bank to North Carolina in the west; also reported from the Florida Keys and from Cuba.[98]

92. Captain Donald Campbell advises us that catches of 1–3 Torpedoes per day were made on 20 out of 50 days (33 fish) between June 16 and September 17, 1947 off the southeastern shore of Vineyard Sound in 30 feet of water in a fish trap set with runner extending in toward shore to the 20-foot line.
93. The most instructive information in this respect dates back many years.
94. Storer, Mem. Amer. Acad. Arts Sci., N. S. *9*, 1867: 245; also Fishes Mass., 1867: 271.
95. Reports by Captain N. E. Atwood, in Storer (Amer. J. Sci., *45*, 1843: 167).
96. By Captain Donald Campbell.
97. For tropical West African references, see Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 121; *70* [2], 1936: 1157) and Poll (Résult. Sci. Exped. oceanogr. Belge Côt. Afr. Atlant. [1848–49], 1951: 79). The relationship of *T. nobiliana* to the Torpedo reported under that specific name from the vicinity of the Cape of Good Hope (Barnard, Ann. S. Afr. Mus., *21*, 1925: 89, by ref. to Thompson [Mar. biol. Rep. Cape Town, *2*, 1914: 159, as *Torpedo hebetans*]; Smith, Sea Fish. S. Afr., 1949: 75) remains to be determined.
98. It has been suggested (Dubois Reymond, Arch. Anat. Physiol., Leipzig [1882], Physiol. Abt., 1882: 400; Rep. Brit. Ass., 1882: 594) that the large Torpedoes that are taken from time to time in British waters may be strays that have drifted across from America in the Gulf Stream. We think it far more likely that the populations of *T. nobiliana* in the two sides of the Atlantic are entirely independent of each other.

Occurrence in the Western Atlantic. The most northeasterly records for *T. nobiliana* off the American Coast are: one from Eastport, Maine, at the mouth of the Bay of Fundy; another, "presumably of this species,"[99] taken in St. Margaret Bay (Nova Scotia) some 30 years ago; and a third caught on a long line set for cod on La Have Bank in 1890, reported by an observer who was undoubtedly well acquainted with *T. nobiliana* at Woods Hole.[100] It has also been taken near Seguin Island, Maine, at the mouth of Casco Bay; in the vicinity of Cape Ann, Massachusetts; in the southern side of Massachusetts Bay near Provincetown and along the outer coast of Cape Cod (see Study Material, p. 96). Localities so distributed show that it is to be expected anywhere along the coast of the Gulf of Maine. Also, a 58-inch specimen was taken on the southwest part of Georges Bank in December 1930. Torpedoes are caught yearly in Buzzards Bay and in Vineyard Sound, while records of long standing indicate its presence off Nantucket Island and the southern shore of Marthas Vineyard. It is reported commonly off Rhode Island and in the vicinity of Block Island, and it has been reported from the vicinity of New York and at localities thence southward, showing that odd specimens are to be expected anywhere along New Jersey and Maryland and within the mouth of Chesapeake Bay.

The status of *T. nobiliana* southward from the region of Cape Lookout is doubtful.[101] An "electric fish" reported from the vicinity of Charleston, South Carolina[102] actually may have been a *Narcine brasiliensis*, as seems to have been true of some of the early records that ostensibly refer to *Torpedo* on the North Carolina Coast.[103] The only mention of its occurrence in Florida waters known to us[104] fails to state whether any specimens were actually examined. It has been mentioned repeatedly as ranging to Cuba, but all these reports appear to emanate from an early reference to a small Electric Ray (360 mm long) of doubtful identity taken near Havana many years ago.[105] And the recent inclusion of it as a member of the fish fauna of the northern Gulf of Mexico[106] also appears to lead back to this doubtful Cuban record or to the Florida Keys report mentioned above; at least we find no mention of it in the several published lists of fishes for the west coast of Florida or for Texas.

Synonyms and Western Atlantic References:

Raja torpedo Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 476 (reported, Georges Bank and near Block Island, by fishermen).

Torpedo nobiliana Bonaparte, Icon. Faun. Ital., *3*, 1835: pl. not numbered (descr., ill. of small specimen, Italy); Storer, Amer. J. Sci., *44*, 1843: 214 (4 ft. 2 in. specimen, Wellfleet, Mass.); Ann. Mag. nat. Hist., *11*, 1843: 326 (same as preceding); Proc. Boston Soc. nat. Hist., *1*, 1844: 94 (same specimen as Storer, 1843); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 145 (listed, New Jersey); Proc. Acad. nat. Sci. Philad.,

99. Vladykov and McKenzie, Proc. N. S. Inst. Sci., 19, 1935: 52.
100. By G. F. O. Hansen, then second mate and later master of the U. S. Bureau of Fisheries schooner GRAMPUS (Smith and Kendall, Rep. U. S. Comm. Fish. [1896], 1897: 169).
101. Two were taken in June of 1941, and several more during the next few weeks, at Cape Lookout, North Carolina.
102. Jordan and Gilbert, Proc. U. S. nat. Mus., 5, 1883: 584.
103. Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 270.
104. "Found occasionally among the Keys," Fowler (Proc. Acad. nat. Sci. Philad., *58*, 1906: 80).
105. By Poey (Repert. Fisico-Nat. Cuba, *2*, 1868: 458) as *Tetronarce occidentalis;* identification doubtful.
106. Gowanloch, Bull. La. Conserv. Dept., 21, 1932: 86; Bull. La. Conserv. Dept., 23, 1933: 238.

74, 1922: 3 (specimen 610 mm, New Jersey); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 62 (descr., meas., weight, Chesapeake Bay); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 31 (diagn., listed, Maryland); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 99 (listed, Manteo, N. Carolina).

Cramp Fish, Storer, Rep. Fish. Rept. Birds Mass., 1839: 201 (Wellfleet, Mass., electric shocks).

Torpedo walshii Thompson, Ann. Mag. nat. Hist., *5*, 1840: 292 (descr., Ireland).

Torpedo emarginata McCoy, Ann. Mag. nat. Hist., *6*, 1841: 407 (descr. of specimen 2 ft. 8 in. long with embryonic pectoral notches; Ireland).

Numb Fish or Cramp Fish, DeKay, Zool. N. Y., 4, 1842: 378 (incl. by ref. to Mitchill, 1815).

Torpedo occidentalis Storer, Amer. J. Sci., *45*, 1843: 165, pl. 3 (descr., ill., size, habits, nos., electric shocks, Provincetown, Mass.); Linsley, Amer. J. Sci., *47*, 1844: 79, footnote (listed, E. side Cape Cod); Storer, Mem. Amer. Acad. Arts Sci., N. S. 2, 1846: 516 (in synopsis); Proc. Boston Soc. nat. Hist., *2*, 1848: 71 (living specimen), 170 (nos., south shore of Marthas Vineyard); Duméril, Rev. Mag. Zool., *4*, 1852: 245 (descr., after Storer, 1843); Hist. Nat. Poiss., *1*, 1865: 513 (descr., color, after Storer); Storer, Mem. Amer. Acad. Arts Sci., (2) *9*, 1867: 247, pl. 39, fig. 5; also Fishes Mass., 1867: 271, pl. 39, fig. 5 (descr., size, ill., habits, electric shocks, nos., season, util., C. Cod, Marthas Vineyard); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 448, footnote 1 (listed, U. S.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (listed, C. Cod to Florida); Uhler and Lugger, Rep. Comm. Fish. Maryland, ed. 1, 1876: 188; ed. 2, 1876: 159 (listed, off Chesapeake Bay); Goode and Bean, Bull. Essex Inst., *11*, 1879: 28 (listed, near C. Ann, Mass.); du Bois Reymond, Arch. Anat. Physiol., Leipzig (1882), Physiol. Abt., 1882: 400; Rep. Brit. Ass., 1882: 592, 594 (no. of columns in electric organ as spec. char., suggests specimens carried to England by Gulf Stream); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 39 (diagn., listed, Atlant. Coast); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed); Wilson, Proc. U. S. nat. Mus., *33*, 1907: 373 (copepod parasites, season, Provincetown, Mass.); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Norman and Fraser, Giant Fishes, 1937: 64 (listed, Atlant. Coast U. S.); Coates and Cox, Zoologica N. Y., *27*, 1942: 25 (electric discharges, nos., season, weight, C. Lookout, N. Carolina).

Torpedo nigra Guichenot, Explor. Alger. Poiss., *5*, 1850: 131, pl. 8 (ill. Algeria; for size, see Duméril [Hist. nat. Poiss., *1*, 1865: 512]).

Narcacion occidentale Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed, E. Coast N. America).

Tetronarce occidentalis Gill, Ann. N. Y. Lyc., *7*, 1862: 387 (type of new genus *Tetronarce*); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 77 (descr., C. Cod to Cuba); Smith and Kendall, Rep. U. S. Comm. Fish. (1896), 1898: 169 (Maine, LaHave Bank); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 11, fig. 33 (ill.); Linton, Bull. U. S. Fish Comm., *19*, 1901: 274, 432 (stom. contents, nos., season, female with young, cestode parasites, Woods Hole); Bean, Bull. N. Y. St. Mus., 60, Zool., *9*, 1903: 51 (descr., color, habits, range); Jordan, Guide to Study Fish., *1*, 1905: 554 (size, cf. European *T. nobiliana* and *T. californica*); Fowler, Proc. Acad. nat. Sci. Philad., *58*, 1906: 80 (listed, Florida Keys); Rep. N. J. Mus. (1906), 1907: 260 (listed, New Jersey); Smith, N. C. geol. econ. Surv., *2*, 1907: 43 (descr., range, size, but previous reports from N. Carolina probably *Narcine*); Sullivan, Bull. U. S. Bur. Fish., *27*, 1907: 10, 13, 15–16, 22 (morphol. of intestine, physiol.); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 13 (New England locals.); Nichols, Abstr. Proc. Linn. Soc. N. Y., 20–23, 1913: 92 (listed, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31*, 1913: 739 (Woods Hole region and Nantucket, weight); Coles, Copeia, 32, 1916: 46 (listed, C. Lookout, N. Carolina); Copeia, 151, 1926: 105 (listed, size, C. Lookout, N. Carolina); Nichols and Breder, Zoologica N. Y., *9*, 1927: 30 (New York and south. New England, size); Jordan, Manual Vert. Anim. NE U. S., 1929: 17 (diagn., Maine southward); Townsend, Guide N. Y. Aquarium, 1937: 41 (near New York).

Torpedo (no scientific name) Couch, Fish. Brit. Isles, *1*, 1867: 119, pl. 39 (habits, electric shocks, ill., Gt. Britain).

Torpedo hebetans (in part) Günther, Cat. Fish. Brit. Mus., *8*, 1870: 449 (*T. nobiliana* Bonaparte 1835 included in synonymy of *T. hebetans* Lowe 1841).

Torpedo (*Gymnotorpedo*) *occidentalis* Fritsch, Arch. Anat. Physiol., Leipzig (1886), Physiol. Abt., 1886: 362, 364 (no. columns in electric organ); Elektr. Fische, *2*, 1890: 14, pls. 1, 3 (cf. other species, no. electric columns, nerve syst., habits, range by ref. to Storer, suggests carried to England by Gulf Stream).

Tetranarce occidentalis Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 222 (listed, C. Cod to Cuba); Smith, Bull. U. S. Fish Comm., *17*, 1898: 89 (nos., season, Woods Hole region); Tracy, 36 Rep. R. I. Comm. inl. Fish., 1906: 47 (off Rhode Island); 40 Rep. R. I. Comm. inl. Fish., 1910: 62 (same as Tracy, 1906); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 27 (listed, C. Cod to Cuba); Wilson, Bull. U. S. nat. Mus., 158, 1932: 429 (copepod parasites, Woods Hole and Provincetown, Mass.); Gowanloch, Bull. La. Dep. Conserv., 23, 1933: 238 (electric organs, size, listed Gulf of Mexico).

Narcacion nobilianus Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 310, pl. 25, fig. 2, pl. 61, figs. 4, 5 (descr., ill. adult and embryo, skel.; American *occidentalis* considered ident. with European *nobilianus*); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 270 (early N. Carolina report probably was *Narcine*); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 24, 25, 64, 84 (season, cestode parasites, Woods Hole); Bigelow and Welsh, Bull. U. S. Bur. Fish., 40 (*1*), 1925: 68 (genl., Gulf of Maine); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 33 (genl.); Gowanloch, Bull. La. Conserv. Dep., 1932: 86 (electric shocks, size, listed Gulf of Mexico); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 35 (descr., ill. after Garman, range); Vladykov and McKenzie, Proc. N. S. Inst. Sci., 19, 1935: 52 (St. Margaret Bay, Nova Scotia); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 325 (season, size, Georges Bank, Provincetown, Mass.).

Narcobatus nobilianus Fowler, Copeia, 31, 1916: 41 (listed, Sandy Hook Bay, New York).

Torpedo Ray, Wilson, Bull. U. S. nat. Mus., 58, 1932: 403 (copepod parasites, Woods Hole).

Doubtful American References:

Tetronarce occidentalis Poey, Repert. Fisico-Nat. Cuba, 2, 1868: 458; also An. Soc. esp. Hist. Nat., *5*, 1876: 402 (Havana specimen referred doubtfully to *T. occidentalis*); Enumerat. Pisc. Cubens., 1875–1876: 206 (listed, Cuba, by ref. to Poey, 1868).

Torpedo occidentalis Jordan and Gilbert, Proc. U. S. nat. Mus., *5*, 1883: 583 (electric fish reported by fishermen, Charleston, S. Carolina, but perhaps *Narcine*; see p. 121); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina).

Not *Raja torpedo* Linnaeus, Syst. Nat., *1*, 1758: 231 (E. Atlant.).

Not *Torpedo occidentalis* Yarrow, Proc. Acad. nat. Sci. Philad. (1877), 1877: 216 (listed, Fort Macon, N. Carolina).[107]

Genus *Narcine* Henle 1834

Narcine Henle, Ueber Narcine, 1834: 2; type species, *Torpedo brasiliensis* Olfers 1831. Brazil.

Generic Synonyms:

Raja (in part) Bloch and Schneider, Syst. Ichthyol., 1801: 359; includes *Raja timlei* Bloch and Schneider, Tranquebar.

Narcobatus (in part) Blainville, Bull. Soc. philom. Paris, 1816: 121; *Narcobatus maculatus* Blainville included, doubtless equals *Raja maculata* Shaw (Gen. Zool., *5* [2], 1804: 316). Indian seas, based on the Temeree of Russell (Fish. Coromandel, *1*, 1803: 1; Coromandel Coast).

Torpedo van Hasselt, Bull. Sci. Nat. Ferussac, *2*, 1824: 90; for *Torpedo timlei* van Hasselt, equals *Raja timlei* Bloch and Schneider 1801.

Syrraxis Jourdan, in Bonaparte, Icon. Faun. Ital., *3*, Pesci, 1841: 6th p. of descr. of *Torpedo narke* (no pagination); type species, *Narcine indica* Henle 1834.

Cyclonarce Gill, Ann. N. Y. Lyc., *7*, 1862: 387; type species, *Narcine timlei* Henle 1834, equals *Raja timlei* Bloch and Schneider 1801.

Gonionarce Gill, Ann. N. Y. Lyc., *7*, 1862: 387; type species, *Narcine indica* Henle 1834, equals *Raja maculata* Shaw 1804. Indian seas.

Narcina Jordan and Seale, Proc. Davenport Acad. Sci., *10*, 1905: pl. 1; evident misprint for *Narcine*.

Narcinops Whitley, Fish. Aust., *1*, 1940: 164; type species, *Narcine tasmaniensis* Richardson 1840. Tasmania.[108]

Not *Torpedo* Houttuyn, Nat. Hist. Dieren, Planten en Mineral., *6*, 1764: 453.

107. It has been pointed out already by Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: 271) that the fish reported to Yarrow by fishermen was "not a ray but the Electric Stargazer (*Astroscopus y-graecum*)."

108. *Narcinops* was separated from *Narcine* as differing from the type species of the latter (*Torpedo brasiliensis* Olfers

Generic Characters. Disc ranging from a little broader than long to a little longer than broad, its anterior margin broadly rounded; outer margin from continuously rounded to weakly concave a little posterior to level of spiracles; posterior contours of pectorals either curving inward and forward to junction with trunk or merging insensibly rearward with sides of latter. Snout in front of eyes rigid to the touch nearly to anterior margin. Tail with a ribband-like membranous fold along each side, its length from tips of pelvics more than six times as great as breadth of mouth, its length from center of cloaca greater than distance from center of cloaca to mouth. Margins of pectorals without papillae, spinous or otherwise. Origin of first dorsal over or slightly posterior to rear ends of bases of pelvics. Pelvics with outer corners ranging from subangular to broadly rounded, their distal margins from weakly convex to more or less deeply concave,[109] their inner posterior margins either united with sides of tail to their tips or free from sides of tail for a shorter or longer distance in both sexes;[110] males with a considerable area of loose flabby skin in the axil of each pelvic fin. Eye fully developed, as large as spiracle in some species, smaller in others. Spiracles either close behind eyes or separated from them by a moderate interspace, their length at least $^1/_3$ as great as distance between spiracles, their margins either smooth or more or less corrugated or with papillae. Nuchal region with a pair of large mucous pores, close together side by side. Nostrils slightly oblique, apparently minute on cursory appearance because they are roofed inwardly by the joint nasal curtain, but actually they are about as long as the breadth of the isthmus between them, or longer. Nasal curtain much broader than long, extending to mouth; posterior margin of nostril also somewhat expanded outwardly as a low flap, directed toward the mouth. Mouth narrow, transverse, approximately straight, and protractile as a short tube, flattened dorsoventrally.[111] Teeth with one sharp cusp. Tooth bands falling considerably short of corners of mouth; largely exposed when mouth is closed in some species but entirely enclosed within the closed mouth in at least one (p. 123). Integument bearing teeth only loosely attached to jaws. Upper and lower jaw cartilages broad, their lateral articulations extensive in area and very firm; a special labial cartilage of two subtriangular elements on either side of mouth; proximal end of upper element attached to upper jaw cartilage, that of lower element to lower jaw cartilage, about midway between symphysis

1831) in "form of body, margin of nasal valves, in having a wider skull and different cartilages" (Whitley, Fish. Aust., *1*, 1940: 164). But the first two differences are not greater than is to be expected between species of a genus with a geographical range as wide as that of *Narcine*. Nor does a somewhat wider skull seem important. Also, the absence of small intermediate cartilaginous elements between rostral and antorbital cartilages and of a transverse foramen in the anterior part of the rostral cartilage in *N. tasmaniensis*, compared with their presence in *N. brasiliensis*, seems more appropriate as a specific than as a generic character.

109. The original illustration of *N. tasmaniensis* (Richardson, Trans. zool. Soc. Lond., *3*, 1849: pl. 2, fig. 2) shows the distal margins of the pelvics as so deeply concave that the posterior part of each fin appears as a distinct lobe. But seemingly this was an exaggeration, for they are represented as only weakly concave in a recent picture of this same species (Whitley, Fish. Aust., *1*, 1940: 165, fig. 186).

110. The pelvics in some are adnate to their tips (e. g., *Narcine timlei*, p. 112), in others (e. g., *N. indica*) the inner pelvic margins are free for only a short distance, in others (e. g., *N. brasiliensis*) the pelvics are free for a somewhat greater distance.

111. In a specimen of *N. timlei*, about 34 cm long, the mouth protruded to a distance of about 35 mm (Annandale, Mem. Indian Mus., *2*, 1909: 44).

and outer articulation; the two elements of each labial cartilage flexibly joined. The presence of these cartilages, combined with the firmness with which the two jaws are articulated, limits the gape of the mouth.[112] Rostral cartilage single but bifid at tip; trough- or shovel-shaped, with a deeper or shallower median depression bounded on either side by a more or less sharply defined ridge; rigid next to cranium but soft and flexible toward its tip; its proximal portion with or without a transverse foramen; anterior margins of antorbital cartilages more or less dissected, with or without one or two isolated cartilages on either side between each of them and rostral cartilage.[113] Each electric organ with an average of 146–428 columns in the species in which they have been counted.[114] Characters otherwise those of the family.

Size. The maximum length definitely reported for *Narcine* appears to be about 30 inches (762 mm),[115] the second longest 18 inches,[116] sizes far below the length reached by species of the genus *Torpedo* (p. 85).

Developmental Stages. The inner walls of the uterus are thickly set with villi (up to 200 per sq. in. of uterine surface), as is generally the case in ovoviviparous batoids. These villi are spatulate in form and are provided with a dense net of capillaries. Apparently they secrete the yellowish milky solution that fills the uterus and probably nourishes the embryo. In embryos at a stage when the external gill filaments still persist, the anterior limits of the pectorals may still be marked by deep notches in the margins of the disc, or the notches may have disappeared already.[117] In either case, the pectoral notches have disappeared before birth in all species of the genus, so far as is known.

Habits. The various species of *Narcine* are most commonly encountered close to land, in water so shoal that they can be taken in seines hauled from shore, or they can be seen lying on bottom. And 60 fathoms appears to be the maximum depth recorded for the genus. They have been described as sluggish in habit. The fact that the protractile mouth cannot be gaped widely would suggest that they subsist on less active and smaller prey than members of the genus *Torpedo* (p. 102). In fact, the stomach contents of the few specimens examined have consisted solely of polychaete worms,

112. These cartilages with their attached muscles were described and accurately pictured for *Narcine brasiliensis* more than a century ago by Henle (Ueber Narcine, 1834: 12, pl. 4, fig. 2); they have been illustrated more recently for *Narke japonica* by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 67, fig. 3).

113. For a general account of the head skeleton with illustrations, see Holmgren (Acta Zool. Stockh., *22*, 1941: 57–59, figs. 50–55).

114. The number of columns in the Indo-Pacific species (*Narcine tasmaniensis*, *N. lingula*, *N. timlei*, and *N. indica*) average from 146–278 per organ, those in adult *N. brasiliensis* (Fritsch, Elektr. Fische, *2*, 1890: 98; Cox and Breder, Zoologica N. Y., *28*, 1943: 46) from as few as 380 to as many as 428.

115. Breder (Bull. Bingham oceanogr. Coll., *2* (1), 1928: 5) for a specimen of *Narcine entemedor;* jaws only.

116. Reported for *N. brasiliensis* (p. 118); also for *N. tasmaniensis* by Whitley (Fish. Aust., *1*, 1940: 164). A two-foot specimen from the west coast of Mexico, reported by Kumada and Hyama (Marine Fish Pac. Coast Mexico, 1937: 21) as a *Narcine*, may not have belonged to that genus, for they describe its snout as "much angular."

117. See Prashad (Rec. Indian Mus., *19*, 1920: 104, pl. 7, figs. 4–9) for an account of the uterine wall in *Narcine indica* Henle 1834 and for illustrations of embryos with the anterior parts of the pectorals still separate from the sides of the head. For illustrations of an embryo of *N. timlei* (which we have examined) at about the same stage in development but with the pectorals fully united with the sides of the head, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 61, fig. 6).

ascidians, amphipods, small shrimps, and other crustacea.[118] Their feeding habits have not been observed, but their known diet and the structure of their jaws and lips suggest that they suck into their protruded mouths whatever soft-bodied animals they may encounter on bottom (or close to it), rather than that they pursue more actively swimming prey.

The electric shocks of *Narcine* are much weaker than those of *Torpedo*, the highest recorded voltage being about 37, and apparently a more active stimulus is required to induce the former to discharge.[119]

Relation to Man. These little Electric Rays, though locally common, have never been of any commercial importance.

Range. Continental waters of the western Atlantic from N. Carolina and Texas to southern Argentina; Pacific Coast of America from the Gulf of California to Panama; Indo-China, China and Japan; Malaysia and East Indies; southeastern and southern Australia (Queensland and Victoria) and Tasmania; India. There is no reliable report of the presence of *Narcine* anywhere in the eastern side of the Atlantic, in the Red Sea, or along the African Coast of the Indian Ocean,[120] unless the limits of the genus be expanded to include the species that are classed here (p. 89) as *Heteronarce*.[121]

Species. Examination of representatives of five of the species concerned[122] from widely separated localities leads to the conclusion that the most useful characters for purposes of specific identification are: (a) distance between eyes and spiracles; (b) shape of caudal; (c) margins of spiracles smooth or corrugated; (d) shape of joint anterior nasal curtain; (e) shape of pelvics; and (f) color in the case of the more conspicuously marked species. The position of the origin of the first dorsal relative to the axils of the pelvics is useful only if the question of sex be taken into account, since males and females differ in this respect. But final diagnoses must await first-hand comparisons between adequate series of the Malaysian species, including a final decision as to whether the *Raja maculata* of Shaw 1804[123] was an earlier name for *Narcine indica* Henle 1834 or a later name for *N. timlei* Bloch and Schneider 1801.

118. Stomach contents have been recorded by Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 247) for *N. entemedor*, and by Richardson (Trans. zool. Soc. Lond., *3*, 1844: 182) for *N. tasmaniensis*. For stomach contents of *N. brasiliensis*, see p. 119.

119. This reluctance, reported by Annandale for the Indian *N. timlei* (Mem. Indian Mus., *2*, 1909: 45), has been emphasized recently by Cox and Breder (Zoologica N. Y., *28*, 1943: 47) for *N. brasiliensis*.

120. Günther's (Cat. Fish. Brit. Mus., *8*, 1870: 453) report of *Narcine brasiliensis* from the Cape of Good Hope probably was an error, for *Narcine* has not been found during recent surveys of the fish fauna of South African waters (von Bonde and Swart, Fish. Mar. biol. Surv. S. Afr., Rep. 3 [1922], 1924, Spec. Rep. 1; Barnard, Ann. S. Afr. Mus., *21* [1], 1925: 91).

121. The type species of *Heteronarce*, *H. garmani* Regan (Ann. Mag. nat. hist., [9] 7, 1921: 414), is reported so far only from the coast of Natal. *Narcine mollis* Lloyd (Rec. Indian Mus., *1*, 1907: 5), also referred to *Heteronarce* by Regan, is known only from the Gulf of Aden.

122. *Narcine brasiliensis* (p. 112); *N. indica* from Penang; *N. lingula* from Penang; *N. timlei* from China; *N. vermiculata*, and the form previously called *N. entemedor* which probably is not separable from *N. brasiliensis*, from the west coast of Central America.

123. Gen. Zool., *5* (2), 1804: 316.

Tentative Key to Species[124]

1a. Spiracles separated from eyes by a distance as long as horizontal diameter of orbit.
tasmaniensis Richardson 1840.
Tasmania (type locality), Victoria, and New South Wales.

1b. Spiracles close behind eyes.

2a. Caudal fin fan-shaped, with more or less definite lower and upper corners, its posterior margin approximately vertical, its lower margin only weakly convex at most.

3a. Disc conspicuously marked above with white vermiculations on a dark ground.
vermiculatus Breder 1928.
Pacific Coast of Mexico.

3b. Disc either plain-colored above or with dark markings on paler ground.

4a. Outer (posterior) margins of pelvics weakly but continously convex or straight.

5a. Margins of spiracles conspicuously corrugate or tuberculate.
brasiliensis (Olfers) 1831,
including *entemedor* Jordan and Starks 1895, p. 120.

5b. Margins of spiracles only faintly tuberculate, if at all so.
lingula Richardson 1846.
Indo-China, China, Japan.

4b. Outer (posterior) margins of pelvics conspicuously concave.
schmitti Hildebrand 1948.[125]
Gulf of California.

2b. Caudal fin ovoid, its posterior margin convex and strongly oblique, its lower margin continuously rounded without definite lower corner.

6a. Posterior parts of pectorals slightly overlapping anterior parts of pelvics; posterior outlines of pectorals definitely though slightly recurved; inner margins of pelvics separate from sides of tail for a short distance anterior to rear tips.
indica Henle 1834.[126]
India, Malaysia, East Indies.

6b. Posterior parts of pectorals not overlapping anterior parts of pelvics; posterior outlines of pectorals not recurved at junction with sides of trunk; inner margins of pelvics united with sides of tail to their tips.

124. *Narcine mollis* Lloyd (Rec. Indian Mus., *1*, 1907: 8) falls in *Heteronarce*, according to the generic definitions adopted here.

125. Smithson. misc. Coll., *110* (9), 1948: 1.

126. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 333) identifies *N. indica* Henle 1834 with *Raja maculata* Shaw 1804 (Gen. Zool., *5* [2], 316), which was based on the Electric Ray pictured by Russell (Fish. Coromandel, *1*, 1803: pl. 1) under the vernacular name "Temeree." But Russell's account and illustration give so little detail that we think it premature to accept this identification until some student is able to re-examine the whole question of the inter-relationships of the Indian species of *Narcine*, especially since Rudolphi (Grundriss Physiol., *1*, 1821: 199) long ago suggested that the Temeree might equal *Narcine timlei* (Bloch and Schneider) 1801, not *N. indica* Henle 1834.

7a. Upper surface of disc conspicuously marked with dark spots; nasal curtain projecting but little, if at all, in the midline.
timlei (Bloch and Schneider) 1801.
India, Malaysia, East Indies, Indo-China to China and Japan.[127]

7b. Upper surface plain-colored; nasal curtain with a distinct projection in the midline. *brunnea* Annandale 1909.
India and Ceylon.[128]

Narcine brasiliensis (Olfers) 1831[129]

Lesser Electric Ray

Figures 24, 25

Study Material. Thirty-five specimens of both sexes, from 110 mm (one embryo with scar, and one newborn) to 450 mm in total length, from Rio de Janeiro and Rio Parahyba, Brazil; from St. Vincent, West Indies; from the Gulf of Campeche; and from New Smyrna Beach and the St. Johns River, Florida (including type of var. *coral-lina* Garman 1881), in Harvard Museum of Comparative Zoology; 19 specimens, including eight embryos 69–81 mm long, from Palmetto Key, Florida, in American Museum of Natural History; 14 embryos, each about 80 mm long, from Long Key, Florida, in U. S. National Museum;[130] and one from off Cape Lookout, North Carolina, from U. S. Fish and Wildlife Service; also three specimens (one male, two females) of the Pacific form that has been known as *Narcine entemedor* Jordan and Starks 1895, 375 to 405 mm long, one from Magdalena Bay, and two from Inez Bay, Gulf of California, in the American Museum of Natural History.

Distinctive Characters. Torpedo nobiliana, *Diplobatis pictus*, and *Benthobatis marcida* are the only other western North Atlantic Rays with which *Narcine brasiliensis* might be confused. It is easily separable from *Torpedo* by the much more strongly convex

127. Prashad (Rec. Indian Mus., *19*, 1920: 99), following Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 300), concluded that *timlei* "is not an Indian form, being confined to the East Indies and Japan." However, the type locality of the species is Tranquebar, southeastern India ("Habitat Tranquebariam . ." Bloch and Schneider, Syst. Ichthyol., 1801: 359).

128. Day (Fish. India, 1875–1878: 733) reported some specimens of *N. timlei* as spotted and others as plain-colored, and it was to the latter that Annandale (Mem. Indian Mus., *2*, 1909: 45) gave the name *N. brunnea*. However, the color patterns of various species of *Narcine* are so variable (p. 117) that it would not be astonishing should the extremes in this respect, represented by *N. timlei* and *N. brunnea*, prove to intergrade. It is also questionable whether or not the degree to which the free edge of the nasal curtain projects in the midline is a dependable specific character. Annandale (Mem. Indian Mus., *2*, 1909: 44, pl. 3A, figs. 1, 2) stated, as an additional specific character of *N. brunnea*, that each of the ridges on the floor and roof of its mouth behind the teeth bears a pair of vertical processes. But the difference in this respect, as illustrated between *timlei* and *brunnea*, is not clear cut. *Narcine firma* Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 30), described from a single Ceylon specimen that seems to be in existence no longer, has already been relegated by Fowler to the synonymy of *N. brunnea*, and justly so in our opinion.

129. The earliest account of this species, with unmistakable illustrations, was by Gronow (Zoophyl., *1* [37], No. 158, 1763: pl. 9, fig. 3) as *Raja laevis*. But Gronow's names have been declared unavailable by the International Commission on Zoological Nomenclature (Opin. 89, Smithson. misc. Coll., 73 [3], 1925: 27).

130. The U. S. National Museum also has specimens, which we have seen, from: Jamaica; Colón; Cozumel; Texas; Pensacola, Key West and Cape Canaveral, Florida; and Cape Lookout, North Carolina.

FIGURE 24. *Narcine brasiliensis*, illustrating variations in color pattern. *A* Male, 396 mm long, from Rio Parahyba, Brazil (Harv. Mus. Comp. Zool., No. 308). *B* Female, 238 mm long, from St. Vincent Island, West Indies (Harv. Mus. Comp. Zool., No. 752). *C* Male, 197 mm long, from Key West, Florida (Harv. Mus. Comp. Zool., No. 44). *D* Male, 152 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36398). *E* Male, 110 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36398). *F* Male, 114 mm long, from Desterio, Brazil (Harv. Mus. Comp. Zool., No. 232).

anterior outline of its disc, by the close proximity of its spiracles to its eyes, by its much narrower mouth with labial cartilages at the corners (this may be felt readily in the larger sizes), and by its much more rigid snout. From the local species of *Benthobatis* it is distinguishable by the tuberculate margins of its spiracles, by the shape of its caudal (cf. Fig. 25A with 26B), by its larger and fully formed eyes, and by the fact that the inner margins of its pelvics are free from the sides of the tail for some distance anterior to their tips.

Description. Proportional dimensions in per cent of total length. Female, 239 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36398). Male, 274 m long, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 643).

Disc: extreme breadth 54.8, 51.3; length 51.0, 47.8.
Snout length: in front of orbits 13.0, 11.3; in front of mouth 15.0, 13.0.
Orbits: horizontal diameter 4.5, 4.0; distance between 5.9, 5.8.
Spiracles: length 2.5, 2.2; distance between 7.7, 8.0.
Mouth: breadth 4.5, 5.1.
Exposed nostrils: distance between inner ends 6.1, 6.6.
Gill openings: lengths, 1st 1.5, 2.2; 3rd 2.1, 2.4, 5th 1.5, 1.8; distance between inner ends, 1st 13.2, 13.0; 5th 7.1, 7.5.
First dorsal fin: vertical height 9.2, 9.9; length of base 7.5, 7.3.
Second dorsal fin: vertical height 8.6, 9.9; length of base 7.5, 8.4.
Pelvics: anterior margin 12.5, 15.0.
Distance: from tip of snout to center of cloaca 52.3, 50.0; from center of cloaca to 1st dorsal 26.5, 24.9; to tip of tail 47.7, 50.0.
Interspace between: 1st and 2nd dorsals 2.7, 4.7; 2nd dorsal and caudal 3.5, 4.7.

Disc subcircular, its anterior contour varying from evenly arcuate to moderately ovoid, its breadth usually a little greater than its length[131] and 49–55 % as great as total length; posterior margins of pectorals moderately recurved in broadly rounded contour. Tail from center of cloaca somewhat shorter to slightly longer (84–101 %) than distance from center of cloaca to tip of snout; rounded above and moderately flattened below, each side with a narrow longitudinal cutaneous fold extending from about opposite or a little anterior to midpoint of base of first dorsal to origin of caudal fin.

Length of snout in front of orbits about 1.6–2.2 times as great as distance between eyes, its length in front of mouth about twice as great as distance between outer ends of nostrils; the two lateral ridges of the trough-shaped rostral cartilage firm to the touch nearly to the anterior margin of the head. Orbits moderately prominent (this may not be the case in preserved specimens). Eyes fully developed and about $^2/_3$ as long as spiracles, oval, their horizontal diameter about 42–78 % as long as distance between orbits. Spiracles close behind eyes, transverse or slightly oblique, squarish in shape when expanded, the margin ringed with a single series of 12 to 20 low rounded papillae

131. Among specimens in our Study Material, the ratios of breadth of disc to its length are from 1.01–1.08; in one Brazilian specimen, probably of this species, this ratio was 0.99. See discussion of *Narcine brachypleura* Ribeiro 1923 (p. 123).

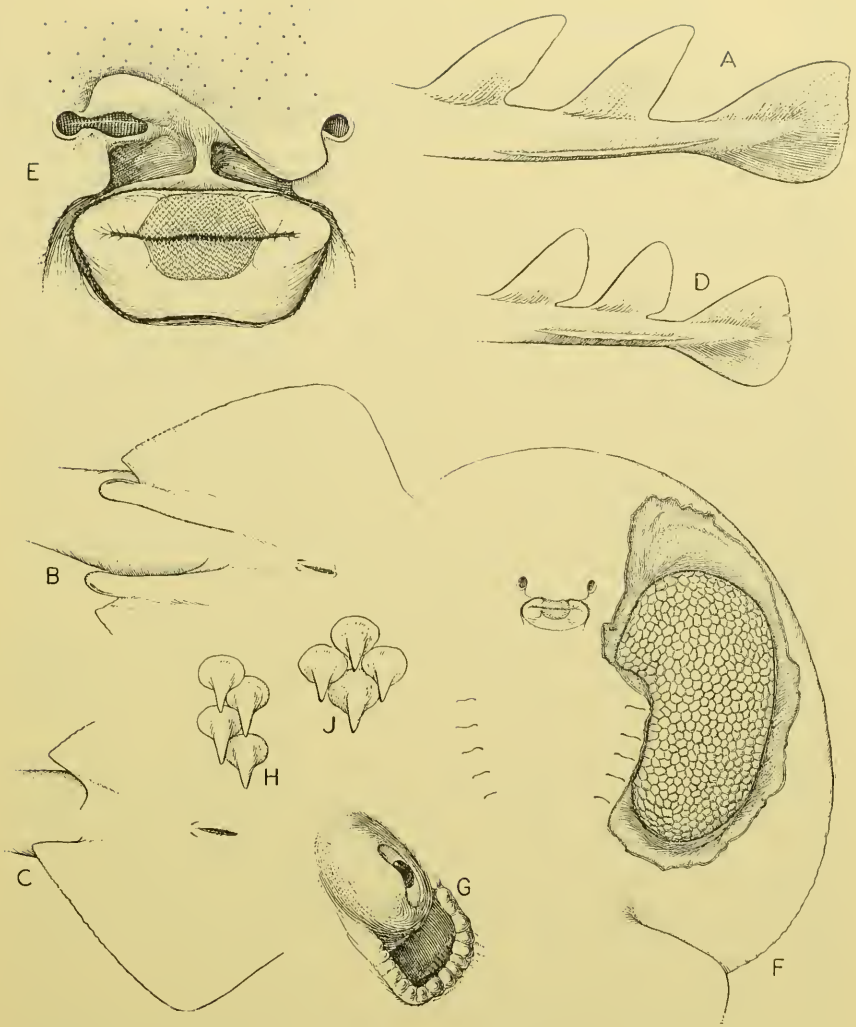

FIGURE 25. *Narcine brasiliensis*. *A* Side view of tail of specimen illustrated in Fig. 24A. *B* Ventral view of pelvics of same. *C* Ventral view of pelvics of female, 450 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 643). *D* Side view of tail of male, 270 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 643). *E* Nostrils and mouth of female, 450 mm long (Harv. Mus. Comp. Zool., No. 643), about 1.5×. *F* Lower surface of disc of female, 258 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36398), with skin dissected away from left-hand side to show electric organ somewhat diagramatically. *G* Eye and spiracle of another female of about same size and from same locality, about 1.2×. *H* Upper teeth of female, 450 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 643), about 15×. *J* Upper teeth of male, 396 mm long, from Rio Parahyba, Brazil (Harv. Mus. Comp. Zool., No. 308), about 15×.

or knobs that vary in distinctness from specimen to specimen. Gill openings noticeably small; first to fourth a little less than half as long as breadth of closed mouth, fifth about 75 % as long as first to fourth; distance between inner ends of gill openings of fifth pair a little smaller than distance between spiracles. Nostrils approximately transverse, their inner ends reaching the deep furrow that surrounds mouth, thus approaching closely to latter though separate from it; all of nostril, except for a small circular aperture at outer end, roofed over by expansion of anterior margin; joint nasal curtain subrectangular with rounded corners, about three times as broad as long, extending rearward to slightly overlap anterior tooth band; free posterior margin of nasal curtain smooth in large specimens, weakly zigzag in small, or perhaps even irregularly and narrowly fringed, with a low median projection in some preserved specimens; outer half of posterior margin of nostril also expanded as a short rounded flap, directed inward and rearward toward the mouth, its free edge either smooth or irregularly zigzag.[132] Mouth transverse, straight, its breadth when closed 77–92 % as great as distance between orbits and about half as great as distance from anterior margin of upper tooth band to tip of snout. Lips conspicuously fleshy at corners, with many short wrinkles. Tooth bands occupying about 60 % of breadth of mouth when closed, the extreme length from front to rear of exposed portion of upper band about half as great as its transverse width from one end to the other; length of lower band from front to rear only about $^1/_3$ as great as its transverse width.

Teeth increasing in number of series with growth from about $^{17}_{17}$ in specimen 239 mm long to about $^{32}_{33}$ in adults; with single conical cusp that is rather sharp; closely crowded; posterior teeth considerably longer than anterior ones, a difference probably resulting from wear; seven to eight rows in function simultaneously on both upper and lower tooth bands.

First and second dorsals approximately equal in size and similar in shape on any given individual; outlines characteristic of young (Fig. 25D) persisting to maturity with little if any alteration in some though changing with growth in others to more narrowly ovoid, with loss of basal recurvature (Fig. 25A); anterior margins a little less than twice as long as bases. Origin of first dorsal posterior to posterior ends of bases of pelvics by a distance a little more than half as great as length of its own base. Interspace between first and second dorsals about 36–74 % as long as base of first dorsal. Distance between second dorsal and caudal 43–65 % as long as base of second dorsal. Caudal subtriangular, nearly equilateral; its posterior margin approximately vertical, moderately and continuously convex in small specimens but becoming less so with growth until nearly straight in adults; upper posterior corner abrupt, the lower corner somewhat more rounded; axis little raised; depth of caudal below tip of axis about equal to height above latter; its upper margin about as long as distance from origin of first dorsal to origin of second dorsal, or a little longer. Pelvics originating below axils of pectorals, which slightly overlap them; their anterior margins in both sexes about 50–55 % as long as distance from origin of pelvics to rear tip and varying

132. We have seen one specimen in which it is smooth on one side, zigzag on the other.

from nearly straight when fins are spread to weakly and continuously convex; rear tips reaching about as far as origin of first dorsal in females and young but as far as midpoint of first dorsal base in adult males; inner margins of pelvics anterior to rear tips free from sides of tail for a distance about as long as base of first dorsal in females, but about 1.3 times that long in adult males.

Proximal edge of upper element of each labial cartilage with a distinct notch; one or two small cartilages intervening between rostral cartilage and antorbital cartilage on each side, or none.[133]

Color. Upper surface dark brown, grayish brown, or leaden to orange or reddish; uniform in some cases but more often irregularly clouded with vaguely defined darker bars or blotches. Most specimens have one band extending across the head anterior to the eyes, but others have another across the posterior part of the head, one or two across the posterior part of the disc extending onto pelvics and tail, and one on the tail extending onto the dorsals; or they may have any or all of these in combination. Late embryos and newborn specimens usually have a varying number of dark rings, ovals, or loops, or darker blotches with pale centers. These markings persist undimmed to maturity in some cases, but more often they become disassociated into separate dots or irregular larger spots that recall the original pattern only faintly at maturity.[134] In fact, they may finally fade out altogether with growth.[135] Lower surface white, either pure or of a yellowish or greenish cast, with the posterior parts of pectorals and outer margins of pelvics dusky-edged. Some specimens show irregular black blotches extending inward and forward from the region of the axils of the pectorals, and some have scattered sooty spots on the posterior parts of the latter or elsewhere on the lower side of the disc.

Remarks. More than a century ago three color varieties were defined but not named.[136] The name *Narcine corallina* has been proposed, first as varietal,[137] next as a full species,[138] and subsequently as a subspecies,[139] for specimens from the Florida Keys in which the ground tint of the upper surface was orange or red. Similarly, West Indian specimens with the dark blotches replaced by loops of small dark spots have been named *Narcine punctata*[140] but subsequently *Narcine brasiliensis* var. *bancrofti*.[141] Still others from Key West, Florida, with dark cloudings but without a superimposed pattern have been made the basis of a separate species, *Narcine umbrosa* Jordan 1884.[142] However, these differences in hue and pattern, while striking enough between the extremes (Fig. 24),

133. Two such intervening cartilages are pictured for *Narcine brasiliensis* by Henle (Ueber Narcine, 1834: pl. 4, figs. 2, 3). However, only one was found on one side and none on the other in a specimen that we dissected.
134. For photographs of a female that falls in this category, and her 15 embryos, see Bean and Weed (Proc. U. S. nat. Mus., *40*, 1911: pls. 10, 11).
135. All of these variations are to be seen among specimens that we have observed from the west and east coasts of Florida. Also Brazilian specimens may have either the clouded variety of coloration (Fig. 24) or may retain the juvenile pattern more or less distinctly (Ribeiro, An. Mus. nac. Rio de J., *14*, 1907: pl. 17).
136. Müller and Henle, Plagiost., 1841: 129.
137. Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 234.
138. Jordan, Proc. U. S. nat. Mus., 7, 1884: 105.
139. Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 270.
140. Garman, Bull. Mus. comp. Zool. Harv., *11*, 1881: 233.
141. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 298.
142. Proc. U. S. nat. Mus., 7, 1884: 105.

intergrade to such a degree that they cannot even be regarded as appropriate bases for separation to subspecies. Indeed, it seems more likely that the variation in color is associated with small local populations, perhaps only temporarily, rather than with any continuing correlation between coloration and geographical distribution.

Relation to Extralimital Species. It has been thought that *Narcine entemedor* Jordan and Starks 1895 of the Pacific Coast of Central America differs from *N. brasiliensis* of the Atlantic in the dimensions and shape of its pelvic fins[143] and in having eyes much smaller than the spiracles. However, in specimens from the Pacific Coast of Central America that we have examined (see Study Material, p. 112) the eyes are actually about as large as the spiracles. Nor does there appear to be any consistent difference between Atlantic and Pacific specimens in shape of pelvic fins or in proportional dimensions in general. While none seen so far from the Pacific had as definite a color pattern as is often shown by *N. brasiliensis*, this is a highly variable character in the latter, as already noted (p. 117).

Size. The average length at birth is about 110–120 mm. Males mature at a length of about 225–250 mm (about 9–10 in.), to judge from the lengths of their claspers (see Study Material, p. 112) and from the sizes of male specimens taken in West Florida waters in company with females containing embryos. Gravid females reported thus far have ranged from 271–320 mm in length. The maximum recorded length (sex not stated) is about 450 mm (17¾ in.), though the species is credited with reaching two feet.[144] Specimens from the west coast of Florida weighed 230–270 g (about 8–10 oz.) at lengths of 240–250 mm, 280–300 g (about 10–11 oz.) at 270–280 mm, and 450–650 g (about 16–23 oz.) at 320–330 mm.[145]

Developmental Stages. Embryos, when nearly ready for birth, have lost all trace of the marginal notches that mark the anterior limits of the pectorals in early stages, and in general form they resemble the adult with the interesting exception that the caudal fins are oval in form, not fan-shaped as are those of their parents. But their color pattern is even more conspicuous than that of the most strongly marked adults.

Four to 15 embryos have been reported in gravid females, and there appears to be a tendency for the majority of the young of a given female to be of one sex.[146]

Habits. This little Electric Ray is found for the most part in water so shallow that it is often taken in beach seines or in trammel nets; barefoot fishermen have been known to tread upon them, and they have been observed buried in the sand with only the eyes and parts of the head exposed.[147] But they sometimes move out into somewhat deeper water, for there is a record of one taken in Argentine waters at a depth of 10 fathoms, another trawled off Corpus Christi, Texas in 14 fathoms, of several taken

143. Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 74.
144. Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 78.
145. Cox and Breder, Zoologica N. Y., *28*, 1943: 50.
146. For earlier illustrations and accounts of embryos, see Bean and Weed (Proc. U. S. nat. Mus., *40*, 1911: 231–232) and Cox and Breder (Zoologica N. Y., *28*, 1943: 46); for the relative numbers of the two sexes, see Breder and Springer (Zoologica N. Y., 25, 1940: 451).
147. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 337.

off Venezuela in 20 fathoms,[148] and one off Cape Lookout, North Carolina in 20 fathoms. There is no reason to suppose, however, that their depth range extends much below this.

They are at home in the highest equatorial temperatures, but they can survive considerable chilling, for some of the Texas captures were made in water as cold as 15.4° C (59.7° F). The few definite determinations of salinity for them, again off Texas, have ranged from 30.6–36.5 ‰, and the fact that they have not been found "in Texas inside waters, except occasionally in the Laguna Madre, which is a peculiar environment with very high salinity at times,"[149] is an additional reason for questioning the correctness of the older reports of them in fresh water.[150]

Of its diet we know only that the stomach of one specimen, taken near Cape Lookout, North Carolina, was full of red annelid worms,[151] and that of another from New Smyrna Beach, Florida, opened by us, contained a single good-sized annelid.

Reports of gravid females have been confined to June and July, whether for Florida or for North Carolina; this suggests that the young are born during the warm months in latitudes where there is a considerable difference in temperature between winter and summer; in tropical latitudes, however, they may be produced throughout the year.

Electric Capabilities. The number of columns in each of the electric organs, which make up about 1/6 of the weight of the fish, ranges from as high as 428 (average of three specimens)[152] to as low as 382 for adults and 286 for embryos;[153] the number of electric plates (or electro-plaxes) averages from 179–288 per column in the outer part of the organ (where the columns are shortest) to 288–482 in the inner part (where longest).

An observer, familiar with *N. brasiliensis* in North Carolina waters, writes that he has been knocked down by their shocks, as have others who have chanced to tread on them while wading barefoot in shallow water. It seems, however, that it is the suddenness rather than the intensity that is responsible in such cases, for the peak voltage for 12 specimens of both sexes in good condition was only from 14–37 volts.[154] To induce a discharge, it has been found necessary "to prod, lightly pinch, or otherwise annoy them .... and it finally developed that a new stimulus was more effective than any one kind often repeated."[155] From this it seems doubtful whether discharges of this particular Electric Ray have any great efficiency as a protective device. This doubt is strengthened by the further observation that specimens kept in a live car did not protect themselves from attacks upon their eyes by small pinfish (*Lagodon rhomboides*),

148. Delsman, Mém. Mus. Hist. nat. Belg., [2] Fasc. 21, 1941: 65.
149. Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22.
150. In the U. S. National Museum there is a specimen labelled "St. Johns River, Florida" (see Study Material, p. 112), but there is no knowing how far upstream it was actually taken, i. e., whether in fresh water or in salt or brackish water near the mouth of the river.
151. Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 160.
152. Fritsch, Elektr. Fische, *2*, 1890: 98.
153. Cox and Breder (Zoologica N. Y., *28*, 1943: 46) give the most complete account of the electric organs of this species.
154. See Cox and Breder (Zoologica N. Y., *28*, 1943: 50) for voltage, current, and power at peak of discharge with various resistances; recorded by oscillograph for two specimens.
155. Cox and Breder, Zoologica N. Y., *28*, 1943: 48.

a species which "has a tendency to pick out the eyes of fish which lie prone on the bottom."[156] Nor does the little that is known of its diet (p. 119) or of that of other members of its genus (p. 109) suggest that the electric organs are likely to be of as much service to them in feeding as they may be to other Electric Rays that prey on actively swimming fishes (p. 102).

Numerical Abundance. No exact information is available as to the numbers of *N. brasiliensis*. But reports that it is taken frequently in trammel nets on the west coast of Florida, plus the fact that considerable numbers are contained in the collections of museums and that they have been reported with considerable frequency from one place or another, suggest that the population within its year-round range is considerably more abundant than is that of its larger relative, *Torpedo nobiliana*. It appears, however, that few take part in the summer migration northward, for the total numbers reported at Cape Lookout in years when watch was kept for them were small: only two in 1909, 11 plus about a dozen more by fishermen in 1910, four in 1911, and 16 in 1912.[157] Also, it seems that few reach the opposite boundary of the species' range, for the number of recorded specimens is only four from Argentine waters.[158]

Relation to Man. The Lesser Electric Ray is of no commercial importance; in fact, we have no evidence that it is brought into tropical fish markets. But a correspondent[159] who has tried them on the table and who has supplied the specimens from the east coast of Florida (listed, p. 112) informs us that they are excellent eating.

Range. Inshore waters of the western Atlantic, from southern Brazil to Florida and Texas; south in small numbers to northern Argentina in about Lat. 39–40° S, and north to North Carolina. It is represented on the Pacific Coast of Central America, Gulf of California to Panama, by a form (*Narcine entemedor* Jordan and Starks 1895) so closely allied that it will probably prove indistinguishable when more fully studied (see discussion, p. 118). *N. brasiliensis* has been reported also from the Cape of Good Hope, but probably not correctly.[160]

Occurrence in the Western Atlantic. This Electric Ray has been reported from localities so widely distributed,[161] and it is so well represented in the larger museums of both America and Europe, that it is to be expected anywhere along the American littoral, provided the type of bottom and depth be suitable, from the coast of southern Brazil at about Lat. 28° S northward along the South American Coast, throughout

156. Cox and Breder, Zoologica N. Y., *28*, 1943: 47.
157. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 337; Gudger, Proc. biol. Soc. Wash., *26*, 1913: 99.
158. Lahille, An. Mus. nac. B. Aires, *34*, 1928: 338. 159. Captain R. A. Howard, A. U. S.
160. Reports of *N. brasiliensis* in South African waters appear to lead back to Duméril's (Hist. Nat. Poiss., *1*, 1865: 515) suggestion that the *Torpedo ocellata* of Quoy and Gaimard (Voy. 'Uranie', Zool., 1824: 199) might be identical with *N. brasiliensis*. But its large mouth (so described by Quoy and Gaimard) seems to locate it in the genus *Torpedo*. In any case, the governmental marine surveys of South African waters have not taken any *Narcine* (von Bonde and Swart, Fish. Mar. biol. Surv. S. Afr., Rep. 3 [1922], Spec. Rep 5, 1924: 14).
161. Santos, Rio de Janeiro and general region, São Salvador (Bahia), Rio Parahyba, and Para in Brazil; Venezuela; Colón; Yucatán; Guadeloupe, Martinique, St. Vincent, Jamaica, and Cuba among the West Indies; the Florida Keys; various Florida localities along the east coast northward to New Smyrna and the St. Johns River, and along the west coast to Pensacola; Corpus Christi and the offing of Aransas Bay in Texas; also listed as a member of the fish fauna of Louisiana.

the Caribbean region in general, to northern Florida on both coasts, to Texas, and perhaps to Louisiana (not yet reported there).

To the northward it has been reported once from Charleston, South Carolina (a newborn specimen), as well as from Southport, Beaufort, and Cape Lookout, North Carolina. The Bight immediately south of the Cape appears to act as a sort of *cul de sac* for such *Narcine* as wander that far north, for 13 out of 23 specimens reported near Cape Lookout during the summers of 1909, 1910, and 1912 were taken in this Bight.[162] This marks the extreme northern limit of its range, so far as known. Southward from southern Brazil it has been reported only from Bahia Samboronbon at the southern side of the entrance to the Rio de la Plata, and from Bahia Blanca on the northern Argentina Coast in about Lat. 39°30′ S.

Captures of *Narcine brasiliensis* off the Texas Coast in the months of September, November, and March show that it winters that far north and probably does likewise at least along the southern part of Florida. However, to the northward along the Atlantic Coast of the United States all the records of it, except one, have been in summer. Here its visits appear also to be brief, for while it reaches Cape Lookout in many summers, if not yearly, it has been found inshore there only between June 27 and July 8.[163] But a few must winter offshore as far north as this, for one was trawled in 20 fathoms off the Cape in February 1950,[164] and two other Torpedo Rays, probably of this species, were reported as taken in 34–35 fathoms nearby in January of that same year.

Synonyms and References:

Torpedo brasiliensis Olfers, die Gattung Torpedo, 1831: 19, pl. 2, fig. 4 (descr., color, ill., Rio de Janeiro, Brazil).

Narcine brasiliensis Henle, Ueber Narcine, 1834: 31, pl. 1, figs. 1, 2, pl. 4, figs. 1–4, 8 (descr., meas., ills., cranium with attached cartilages, teeth; Rio de Janeiro); Müller and Henle, Plagiost., 1841: 129 (descr. meas., color varieties, Rio de Janeiro and W. Indies); Duméril, Rev. Mag. Zool., (2) *4*, 1852: 272 (descr., color, Brazil, Martinique, Guadeloupe);[165] Hist. Nat. Poiss., *1*, 1865: 514, pl. 11, fig. 3 (descr. color, ills. mouth, teeth; Antilles and Brazil); Kner, 'Novara' Exped., Zool., *1*, Fische, *5*, 1865: 418 (descr., color variations, size; Rio de Janeiro); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 453 (diagn., Para, Caribbean, Cuba, but ref. to C. of Good Hope probably erroneous; see p. 120, footnote 160); Goode and Bean, Proc. U. S. nat. Mus., *5*, 1882: 240 (listed, Gulf of Mexico); Jordan, Proc. U. S. nat. Mus., *7*, 1884: 105 (cf. *N. umbrosa* Jordan, n. sp.); Fritsch, Arch. Anat. Physiol., Leipzig (1886), Physiol. Abt., 1886: 353 (av. no. electric columns); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed, W. Indies and Florida Keys); Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 93, pl. 33 (mucous canal syst.); Bean, Bull. U. S. Fish Comm., *8*, 1890: 206 (listed, Cozumel, Yucatán); Fritsch, Elektr. Fische, *2*, 1890: 41, 98, pl. 9, figs. 17, 18, pl. 10, fig. 20 (descr., varieties, av. no. of columns in electric organ, ills.); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 78 (descr., W. Indies and Brazil to Key West and Pensacola, Florida); Rep. U. S. Comm. Fish. (1895), 1896: 222 (listed, W. Indies and Brazil to Key West and Pensacola, Florida); Jordan and Rutter, Proc. Acad. nat. Sci. Philad., *49*, 1897: 92 (listed, Jamaica); Duerden, J. Inst. Jamaica, *2*, 1899: 614 (listed, Jamaica); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (listed, Florida Keys, Key West and Pensacola);

162. Gudger, Proc. biol. Soc. Wash., *26*, 1913: 99.

163. Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 33.

164. Specimen 250 mm long, examined by us, trawled by the U. S. Fish and Wildlife Service steamer Albatross III, Lat. 34°01′ N, Long. 76°23′ W.

165. Credited by Duméril (1852, 1865) to the Cape of Good Hope by reference to the *Torpedo ocellata* of Quoy and Gaimard (Voy. 'Uranie', Zool., 1824: 199); but the latter probably was not a *Narcine* (see p. 120).

Jordan and Evermann, Bull. U. S. nat. Mus., *47* (4), 1900: pl. 13, figs. 35, 35a (ills.); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 81 (listed, S. Salvador de Bahia, Brazil); Werner, Zool. Jb., Syst. Abt. *21*, 1904: 296 (listed, Jamaica); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 180, 208, pl. 17 (diagn., refs., photo, Rio de Janeiro to Pensacola, Florida); Aller, Science, N. S. *31*, 1910: 712 (listed, C. Lookout, N. Carolina); Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 337 (habits, electric shocks, nos., 1909, 1910; C. Lookout, N. Carolina); Eigenmann, Rep. Princeton Exped. Patagonia, *3* (4), 1910: 377 (entering rivers); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 473 (listed, Key West, Florida); Bean and Weed, Proc. U. S. nat. Mus., *40*, 1911: 231, pls. 10, 11 (colors, sizes, photos, embryos and adult; Long Key, Florida); Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 33 (abundance, season, no. embryos; C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 101 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 297, pl. 26, fig. 1 (descr., ill., Brazil); Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 157, 158 (stom. contents, nos., C. Lookout, N. Carolina); Proc. biol. Soc. Wash., *26*, 1913: 99 (nos., C. Lookout, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 93 (season, C. Lookout, N. Carolina); Copeia, 32, 1916: 46 (doubts taxonomic value of color); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Santos, Ilha San Sebastiao and Ubatuba, Brazil); Lahille, Physis B. Aires, 5, 1921: 63 (listed, Argentina); Fowler, Proc. biol. Soc. Wash., *36*, 1923: 28 (listed, Key West, Florida); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 73, pl. 3 (descr., color, ill., Colón); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 37, pl. 18 (diagn., cf. *Narcine brachypleura* Ribeiro, n. sp., photo, Pensacola, Florida to Rio de Janeiro); Borodin, Bull. Vanderbilt Oceanogr. (Mar.) Mus., *1* (1), 1928: 5 (listed, no local.); Lahille, An. Mus. nac. B. Aires, *34*, 1928: 338, text fig. 27 (meas., discuss., ill., Bahia Samborombón and Isla Verde, Bahia Blanca, Argentina); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 33 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 17 (genl.); Luderwaldt, Rev. Mus. paul., 16, 1929: 40 (listed, Ilha São Sebastiao, Brazil); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 27 (listed, Brazil to Key West and N. Carolina); Gowanloch, Bull. La. Conserv. Dep., 21, 1932: 86 (included in Gulf Mexico fish fauna); Bull. La. Conserv. Dep., 23, 1933: 239 (ill. after Meek and Hildebrand, 1923; listed, Louisiana); Beltran, List. Peces Mexicanos, 1934: 12 (listed, Mexico; not seen); Pozzi and Borodale, An. Soc. cient. argent., *120*, 1935: 154 (listed, Argentina, Lat. 39°30′ S); Bere, Amer. Midl. Nat., *17*, 1936: 582 (copepod parasites, Lemon Bay, W. Florida); Smith, H. W., Biol. Rev. (Cambridge), *11*, 1936: 65 (in fresh water by ref. to Eigenmann, 1909); Breder and Springer, Zoologica N. Y., *25*, 1940: 431 (electric discharges, sex ratios of embryos, Palmetto Key and Punta Gorda, Florida); Delsman, Mém. Mus. Hist. nat. Belg., (2) Fasc. 21, 1941: 65 (depth, Venezuela); Fowler, Proc. Acad. nat. Sci. Philad., *93*, 1941: 82 (listed, Sanibel, Florida); Hildebrand, Copeia, 1941: 222 (listed, C. Lookout, N. Carolina); Röhl, Fauna Descript. Venezuela, 1942: 370 (listed, Venezuela; not seen); Cox and Breder, Zoologica N. Y., *28*, 1943: 45 (meas. adults, embryo, color pattern, electric organs, meas. of discharges by oscillograph; Palmetto Key, Florida); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Jamaica; Panama); Monogr. Acad. nat. Sci. Philad., 7, 1945: 98, 160, 264, 371 (listed, Southport, N. Carolina; Charleston, S. Carolina; Boca Chica and Key West, Florida; Texas); Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 21 (colors of young, temp., salinities, season; Laguna Madre, Texas, and Gulf of Mexico off Aransas Bay); Schultz, Proc. U. S. nat. Mus., *99*, 1949: 33 (listed, Venezuela).

Torpedo bancrofti Griffith, in Cuvier, Anim. Kingd., *10*, 1834: pl. 34 (colored ill., no local.).

Torpedo pictus Gray, Cat. Fish. Coll. and Descr. by L. T. Gronow, in Brit. Mus., 1854: 13 (diagn., Antilles).

Narcine brasiliensis var. *punctatus* Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 233 (color, cf. *N. brasiliensis*; St. Vincent, W. Indies).

Narcine brasiliensis var. *corallina* Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 234 (color, Key West, Florida); Mem. Harv. Mus. comp. Zool., *36*, 1913: 298, pl. 26, fig. 3 (color, ill., Florida Keys).

Narcine corallina Jordan, Proc. U. S. nat. Mus., 7, 1884: 105 (var. *corallina* Garman 1881, recognized as variety of species).

Narcine umbrosa Jordan, Proc. U. S. nat. Mus., 7, 1884: 105 (descr., Key West, Florida, based on dark-blotched specimens).

Narcine, no spec. name, Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 33 (embryos).

Narcine brasiliensis var. *bancrofti* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 298, pl. 26, fig. 3 (color, ill., Jamaica to St. Vincent).

Narcine brasiliensis corallina Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 270 (descr., ill. teeth, rep. by Jenkins,

1887, of *Torpedo occidentalis* was *Narcine brasiliensis*; C. Lookout, N. Carolina); Coles, Copeia, 32, 1916: 46 (specific status).

Probable Synonyms:

?*Torpedo occidentalis* Jenkins, Johns Hopkins Univ. Stud. Biol., *4*, 1887: 84 (listed, Beaufort, N. Carolina).

Narcine entemedor Jordan and Starks, Proc. Calif. Acad. Sci., (2) *5*, 1895: 387 (descr., nos., La Paz, Mazatlan, Mexico); Gilbert and Starks, Mem. Calif. Acad. Sci., *4*, 1904: 15, 207 (descr., Panama Bay); Osburn and Nichols, Bull. Amer. Mus. nat. Hist., *35*, 1916: 144 (Pacif. Coast, Mexico); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 74 (cf. *N. brasiliensis*); Breder, Bull. Bingham oceanogr. Coll., *2* (1), 1928: 5, fig. 2 (color, photos, Pacif. Coast, Mexico); Beebe and Tee-Van, Zoologica N. Y., *28*, 1941: 247 (color, ill., Gulf of California).

Tetronarce occidentalis Smith, N. C. geol. econ. Surv., *2*, 1907: 43 (at least in part, C. Lookout, N. Carolina).

Narcine brachypleura Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 36, pls. 16, 17 (diagn., photos, adult male, Brazil, supposed to differ from *N. brasiliensis* in relatively narrower disc, but probably only an extreme variant).

Doubtful Synonyms:

Narcine nigra Duméril, Rev. Mag. Zool., (2) *4*, 1852: 276 (cf. *N. brasiliensis*, Brazil); Hist. Nat. Poiss., *1*, 1865: 515, pl. 11, figs. 4, 4a (descr., color, ill. mouth, teeth, supposed to differ from *N. brasiliensis* in shape of fins, rounded teeth and smaller eye; only one specimen seen); Bertin, Bull. Mus. Hist. nat. Paris, (2) *11*, 1939: 82 (type specimen in Paris).

Genus *Diplobatis* Bigelow and Schroeder 1948

Diplobatis Bigelow and Schroeder, J. Mar. Res., *7* (3), 1948: 562; type species, *Discopyge ommata* Jordan and Gilbert 1890. Pacific Ocean, off coast of Columbia, 33 fathoms.

Generic Characters. Nostril subdivided about midway of its length into two separate apertures by a cross bridge of stiff tissue. Teeth entirely concealed within mouth when latter is retracted and closed.[166] Median sector of each lip marked off at either end by a deep transverse groove when the mouth is retracted. Characters otherwise those of *Narcine* (p. 108).

Size. The largest specimen reported was only 198 mm long.

Range. Known only from the coast of British Guiana in the Atlantic and from the Gulf of California to Panama in the Pacific.

Species. Two species have been described, *D. pictus* from the Atlantic and *D. ommata* from the Pacific. *D. pictus* is distinguished from *D. ommata* by angular pelvics which are evenly rounded along their outer margins in the latter. *D. pictus* has a disc no wider than long and the tips of its dorsal and caudal fins are pointed, whereas in *D. ommata* the disc is wider than long and the tips of the dorsal and caudal fins are rounded. A conspicuous circular marking on the center of the disc, present on *D. ommata*, is lacking on *D. pictus*.

Key to Species

1a. Disc scarcely as wide as long; tips of dorsals and caudal pointed; anterior margin of pelvics not concealed by pectorals. *pictus* Palmer 1950, p. 124.

166. In all other genera of the family in which the mouth is protractile (*Narcine*, *Benthobatis*, *Discopyge*, and probably *Heteronarce*), the tooth bands extend so far forward that several of the anterior rows of teeth are fully exposed even when the mouth is tightly closed.

1b. Disc wider than long; tips of dorsals and caudal rounded; anterior margin of pelvics concealed by pectorals. *ommata* (Jordan and Gilbert) 1890. Eastern Pacific from Gulf of California to Panama.

Diplobatis pictus Palmer 1950

Figure 25 α

Study Material. None.

Distinctive Characters. The closest relatives of *D. pictus* in the western Atlantic are *Benthobatis marcida*, *Torpedo nobiliana*, and *Narcine brasiliensis*. It may be separated from *B. marcida* by its relatively large eyes, from *T. nobiliana* by the strongly convex anterior outline of its disc and from *N. brasiliensis*, which it most closely resembles, by its divided nostrils and concealed teeth (p. 123).

Description. Proportional dimensions in per cent of total length. Female, 137 mm long, holotype, from off Georgetown, British Guiana (British Museum [Natural History]).[167]

Disc: extreme breadth 46.7; length 47.5.
Snout length: in front of orbits 10.9; in front of mouth 13.1.
Orbits: horizontal diameter 3.6; distance between 6.6.
Spiracles: length 3.3; distance between 6.6.
Mouth: breadth 6.6.
Nostrils: distance between inner ends 5.1.
Gill openings: lengths, 1st 1.5; 3rd 1.8; 5th 1.5; distance between inner ends, 1st 13.9; 5th 9.5.
First dorsal fin: vertical height 8.0; length of base 6.6.
Second dorsal fin: vertical height 8.7; length of base 6.2.
Caudal fin: upper anterior margin 13.9; lower anterior margin 13.2.
Pelvics: anterior margin 14.6.
Distance: from tip of snout to center of cloaca 51.8; from center of cloaca to tip of tail 48.2.
Interspace between: 1st and 2nd dorsals 3.6; 2nd dorsal and caudal 5.8.

"Disc obtusely rounded, spade-shaped, its greatest width being opposite the last gill-cleft. Margin of snout elliptical. Length of disc equal to its greatest width, contained 2.1 times in total length and 1.9 times in length to caudal notch. Interorbital width twice in length of snout (preocular). Spiracles, greatest length of which is contained twice in interspiracular width, situated immediately behind the orbits. Posterior margin of each spiracle fringed with 7–8 small papillae. Interspiracular width contained twice in pre-oral length of snout plus nasal curtain. Anterior aperture of nostril exposed, separated by a bridge of tissue from the concealed posterior aperture. Nasal curtain much wider than long, its free edge slightly crenulated. Mouth narrow, pro-

167. These proportions were furnished by G. Palmer, Dept. of Zoology, British Museum (Natural History).

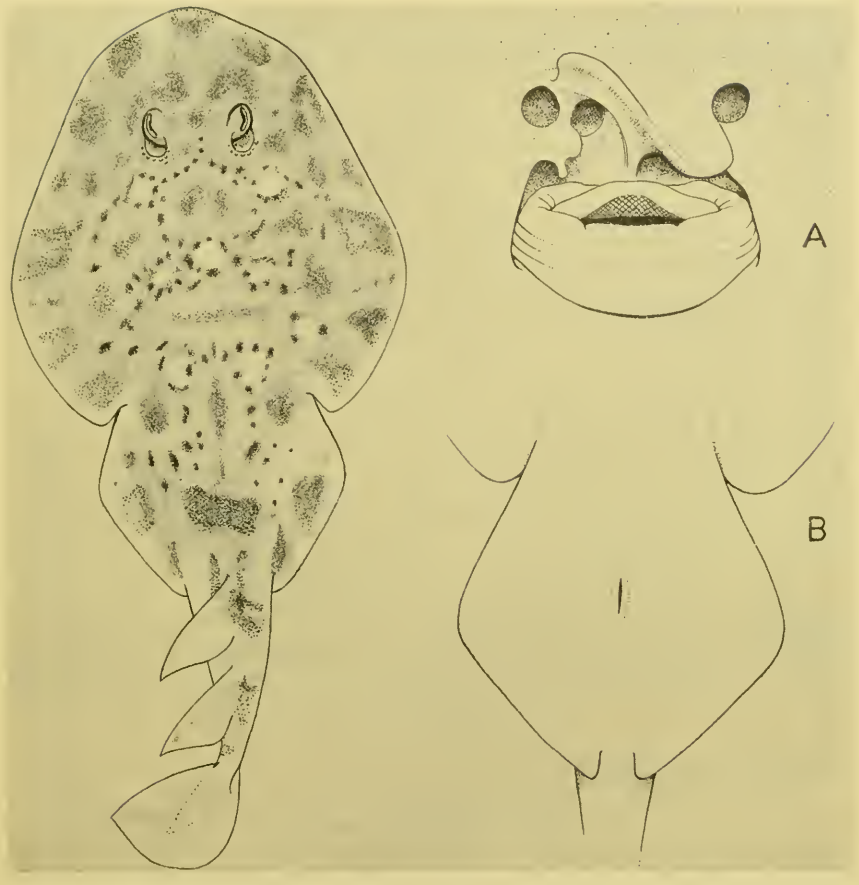

FIGURE 25a. *Diplobatis pictus*, holotype, female, 137 mm long. *A* Right-hand side of nasal curtain raised to show the transverse division of the nasal aperture, 3×. *B* Ventral view of pelvic fins, 1.5×. From G. Palmer.

tractile. Teeth diamond-shaped, in bands, each tooth with a small pointed denticle at its posterior angle directed inwards. Teeth concealed by lips when mouth is fully retracted and closed. The first dorsal commences slightly in advance of a vertical from the posterior edge of the pelvics. The base of the first dorsal a little longer than that of the second dorsal. Tail compressed dorso-ventrally, its depth 1.3 in its width immediately before origin of second dorsal. Two lateral dermal folds, commencing below posterior end of first dorsal base and terminating below caudal notch. Length of tail,

measured from posterior end of slit-like vent to caudal notch, 1.3 in length of disc. Caudal fin broad, almost as deep as long. The dorsal and ventral edges nearly straight, posterior margin rounded. Upper lobe a little longer and more acute than lower. Skin smooth. Pelvic fins separate one from the other and free from the tail at their extreme tips. Their outer anterior margins not concealed by posterior end of pectorals.

Colour in Spirits. Dorsal surface light brown, overlaid with a series of darker brown blotches and white and brown spots. There is a series of irregularly rounded dark brown blotches arranged symmetrically along the outer margins of the pectorals and pelvics, with another pair immediately in front of the eyes. Behind the spiracles and covering the centre of the disc and anterior part of the tail is a series of scattered dark brown spots, interspersed with some white spots and larger dark brown blotches. Dorsals and caudal light brown. At the base of both dorsal fins is a dark brown blotch which extends a short way on to the fins. Near the tip of each dorsal is a dark brown band. The caudal fin is crossed by two brown bands, one near the base, the other near the tip. A narrow band of white along the free margins of pectorals and pelvics. Ventral surface white."[168]

Size. The single specimen known was 137 mm in total length and it is probable that the species does not reach a large size.

Developmental Stages. Nothing is known. The one specimen described was a female, probably immature.

Habits. There is no information as to the breeding habits or the diet of this species.

Range. Known only from off Georgetown, British Guiana.

Reference:

Diplobatis pictus Palmer, Ann. Mag. nat. Hist., (12) *3*, 1950: 480 (descr. holotype).

Genus *Benthobatis* Alcock 1898

Benthobatis Alcock, Ann. Mag. nat. Hist., (7) *2*, 1898: 144; type species, *B. moresbyi* Alcock. India, off Travancore Coast, 430 fathoms.

Generic Characters. Benthobatis agrees with *Narcine* in its relative length of tail, shapes of fins, wholly naked skin, proportions of anterior nasal flap, protractile mouth with labial cartilages, and single cusp on teeth. But it differs from *Narcine* in that the eyes are either entirely rudimentary or at least minute and seemingly blind, the cutaneous folds along the tail are absent or replaced at most by a low fleshy ridge, and the spiracles are relatively smaller. In known species the caudal is oval, its lower posterior contour continuously rounded. Pelvics attached to sides of tail to their tips in some species, perhaps in all.[169] Skin in fresh specimens soft and loose, the body limp and flaccid.[170] The rostral cartilage is like that in *Narcine*, but with its lateral ridges softer

168. From Palmer, Ann. Mag. nat. Hist., (12) *3*, 1950: 480.

169. This is the case in *Benthobatis marcida* (p. 131, Fig. 26). But the account and illustration of *B. moresbyi* (Alcock, Ann. Mag. nat. Hist., [7] *2*, 1898: 145; Ill. Zool. 'Investigator', *4*, 1899, pl. 26, fig. 1) fail to cover this point.

170. This was the case in the considerable series of specimens from Cuban waters listed on p. 128, and the skin was so

and moderately divergent anteriorly; the antorbital cartilages are directed almost transversely outward, their tips with several branches.

Size. The maximum length recorded for any member of the genus is 490 mm ($19^{9}/_{16}$ in., p. 131).

Range. Benthobatis has been found only on the continental slope off South Carolina and northern Florida in 353 to 504 fathoms, along the northern coast of Cuba from 150 to 351 fathoms, off Travancore in India, and in the eastern side of the Arabian Sea at 430 and 585 fathoms.

The depths of capture, its apparent blindness, and the flabbiness of its body, suggest that *Benthobatis* is confined to at least moderately deep water. Beyond this, nothing whatever is known of the habits of the genus. Its embryos have not been seen. The capture of the considerable series (listed, p. 128) by the Atlantis in 1938 and 1939 shows that it is more plentiful in suitable locations, latitudes and depths than previous information might have suggested.

Species. Three species have been named: *B. moresbyi* Alcock 1898,[171] from the coast of India and Arabian Sea; *B. marcida* and *B. cervina* Bean and Weed 1909,[172] from the continental slope of the northeastern United States. *B. moresbyi* is distinguished by its uniformly velvet black hue from its Atlantic relative (or relatives) which are fawn-colored with white markings above and white below. Also, the disc of *B. moresbyi* is pictured[173] as being considerably narrower relatively than that in *B. marcida*. But the only account of *B. moresbyi* is so brief that proportional comparisons in other respects must await re-examination of it.

Examination of the type specimens[174] of the two forms that have been named from the Atlantic has convinced us that they represent a single species. Indeed, in the original accounts the only comparison made between them states that the eyes of *B. cervina* are less reduced than those of *B. marcida*.

Key to Species

1a. Fawn-colored above, with white markings; white below.
marcida Bean and Weed 1909, p. 128.

1b. Purplish-black above and perhaps below.[175]
moresbyi Alcock 1898.
Off Travancore Coast, southern India, and eastern side of Arabian Gulf.[176]

described in the original account of the type species of the genus. However, other specimens that we have seen are firmer and the skins much stiffer, doubtless due to preservation in strong alcohol.

171. Ann. Mag. nat. Hist., (7) *2*, 1898: 145.
172. Proc. U. S. nat. Mus., *36*, 1909: 677, 679.
173. Alcock, Ill. Zool. 'Investigator', *4*, 1899: pl. 26, fig. 1.
174. Now in the U. S. National Museum.
175. It is not clear from the original account of *B. moresbyi* (Alcock, Ann. Mag. nat. Hist., [7] *2*, 1898: 145) whether the purplish-black color is confined to the upper surface or whether it extends to the lower surface as well.
176. For list of references, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 339).

Benthobatis marcida Bean and Weed 1909

Deep-sea Electric Ray

Figure 26

Study Material. Five specimens, 167 to 490 mm long, including the types of *Benthobatis marcida* and *B. cervina* Bean and Weed 1909,[177] trawled on the continental slope off South Carolina and northern and middle Florida in 353–504 fathoms, in U. S. National Museum; also 60 specimens, 81 to 207 mm long, trawled in 1938 and 1939 by the Atlantis in 150–351 fathoms at 26 localities scattered along the northern coast of Cuba.[178]

Distinctive Characters. The only Rays in the western North Atlantic with which *Benthobatis marcida* might be confused are *Torpedo*, *Narcine*, and *Diplobatis*. It is easily separable from *T. nobiliana* by its much narrower protractile mouth and by the minuteness of its eyes. It is distinguishable from *Narcine brasiliensis* (which it resembles in nature of mouth) by its degenerate eyes, by the oval shape of its caudal, by the relatively much greater length of its head anterior to the spiracles, by the union of the inner margins of its pelvics to their tips with the sides of the tail, by the replacement of the lateral membranous folds along the tail (characteristic of the genus *Narcine*) with low fleshy ridges, and by the softness and limpness of its body and skin (unless hardened in alcohol). Its nostrils separate it from *Diplobatis*.

Description. Proportional dimensions in per cent of total length. Male, 184 mm, from off Matanzas, Cuba (Harv. Mus. Comp. Zool., No. 36984). Female, 430 mm, off S. Carolina, Lat. 32°39′ N, Long. 77°01′ W (U. S. Nat. Mus., No. 37886).

Disc: extreme breadth 38.7, 40.5; length 42.3, 42.6.

Snout length: in front of eyes 13.6, 13.5; in front of mouth 12.5, 14.4.

Eyes: horizontal diameter 0.0, 0.3; distance between —, 7.5.

Spiracles: length 2.2, 2.1; distance between 7.6, 7.3.

Mouth: breadth 4.5, 4.9.

Exposed nostrils: distance between inner ends 7.4, 6.3.

Gill openings: lengths, 1st 1.9, 2.2; 3rd 1.9, 2.3; 5th 1.3, 2.0; distance between inner ends, 1st 12.2, 11.4; 5th 7.9, 8.1.

First dorsal fin: vertical height 4.6, 5.1; length of base 6.0, 7.7.

Second dorsal fin: vertical height 6.0, 5.8; length of base 6.0, 7.7.

Caudal fin: upper anterior margin 18.0, 19.3.

Pelvics: anterior margin 9.8, 8.4.

Distance: from tip of snout to center of cloaca 48.3, 45.7; from center of cloaca to tip of tail 51.7, 54.3; from snout to origin of 1st dorsal —, 53.7.

Interspace between: 1st and 2nd dorsals 6.0, 6.1; 2nd dorsal and caudal 5.5, 5.8.

177. Albatross Sta. 2626, Lat. 32°28′ N, Long. 77°21′ W, 353 fath.; Sta. 2660, Lat. 28°40′ N, Long. 78°46′ W, 504 fath.; Sta. 2664, Lat. 29°41′ N, Long. 79°55′ W, 373 fath.; Sta. 2676, Lat. 32°39′ N, Long. 77°01′ W, 407 fath.

178. Atlantis Sta. 2938, 2980, 2981, 2982, 2983, 2984, 2999, 3305, 3387, 3388, 3391, 3392, 3410, 3412, 3413, 3414, 3416, 3417, 3418, 3421, 3422, 3428, 3436, 3437, 3478, 3482; for precise localities and depths, see Chace (Contrib. No. 274, Woods Hole oceanogr. Inst., 1940).

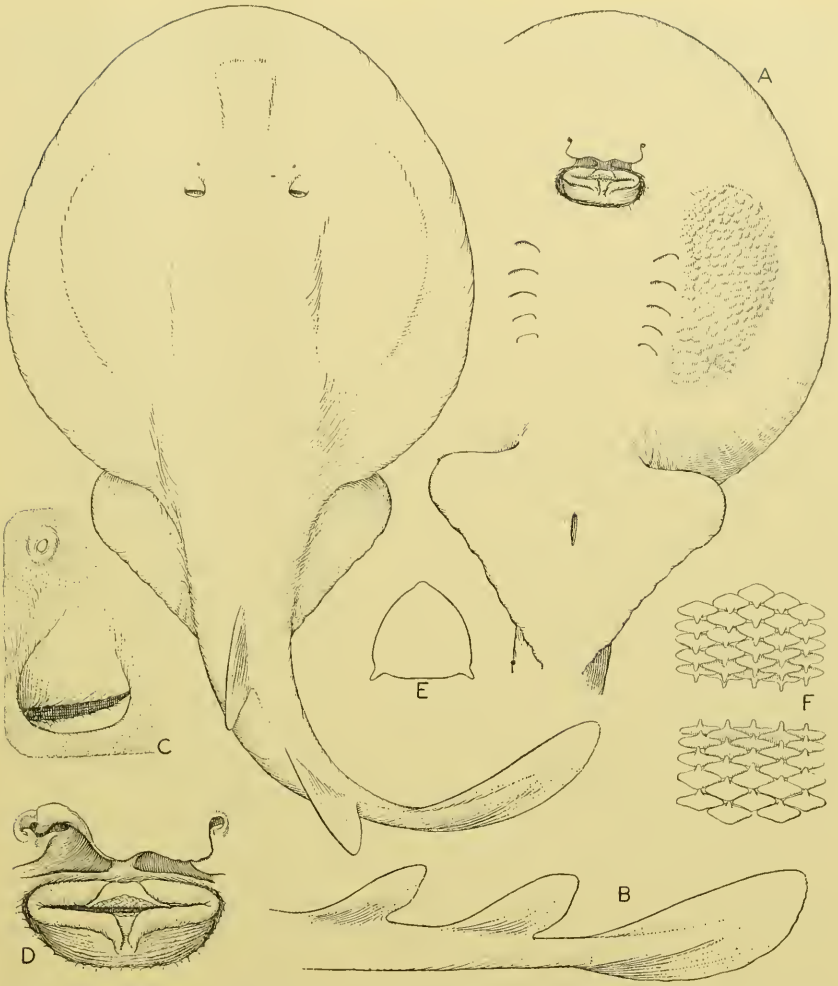

FIGURE 26. *Benthobatis marcida*, female, 430 mm long, from off Charleston, S. Carolina, Lat. 32°39′ N, Long. 77°01′ W (U. S. Nat. Mus., No. 37886). *A* Ventral view with electric organs visible through the skin. *B* Side view of tail. *C* Eye and spiracle, about 2.7×. *D* Nostril and mouth, about 1.2×. *E* Cross section of tail between second dorsal and caudal fins, about 1.4×. *F* Upper and lower teeth from center of mouth, about 6.8×.

Disc rounded, about as long as broad or a little longer (maximum ratio, length to breadth, about 1.2), the posterior margins of pectorals merging gradually with sides

of trunk (not appreciably recurved). Tail from center of cloaca about as long as distance from center of cloaca to tip of snout on small specimens but a little longer relatively in adults; rounded above, moderately flattened below; sides of tail evenly rounded in small specimens (at least in most cases), but each with a low dermal ridge in adults from about opposite origin of first dorsal to origin of caudal.

Snout anterior to spiracles about twice as long as breadth between spiracles, its length in front of mouth about 2.5 times as great as distance between outer ends of nostrils. Eyes separated from spiracles by a distance about equal to length of latter; minute, apparently nonfunctional, entirely covered over with skin and thus largely concealed in small specimens and in some mature ones, but exposed as dark dots up to one mm in diameter on other large specimens. Spiracles transverse or slightly oblique, about $^1/_4$–$^1/_5$ as long as distance between them, rounded posteriorly when expanded, their margins perfectly smooth. A pair of small mucous pores on nuchal region visible under a lens. All gill openings about as long as spiracle; distance between inner ends of first pair about 1.6 times as long as distance between spiracles; distance between inner ends of those of fifth pair about 65–72 % as great as that between first pair. Exposed portions of nasal apertures minute (even smaller than in *Narcine*); the isthmus separating their inner ends (visible only when nasal curtain is lifted) about half as broad as mouth when latter is retracted and closed (thus broader relatively than in *N. brasiliensis*); nasal curtain thick, fleshy, about $^1/_4$ as long as broad, its free margin with three low rounded expansions of about equal lengths; outer part of rear margin of nostril expanded as a low, rounded, fleshy lobe directed inward toward isthmus between both nostrils. Mouth with thick, wrinkled lips and surrounded by a deep moat; about $^2/_3$–$^3/_4$ as wide as distance between spiracles when retracted and closed; forming a short tube (8 mm long in a 220-mm specimen) when protracted and opened. Tooth bands occupying $^2/_3$–$^3/_4$ of breadth of mouth.

Teeth $\frac{12}{12}$ to $\frac{20}{20}$; closely crowded in quincunx arrangement, the bases subquadrangular; those of the younger series with a single slender cusp blunted at tip, directed rearward into the mouth; those of older series (exposed when mouth is closed) with cusps partly or wholly worn down; about seven rows in function simultaneously along centers of tooth bands, four to five rows toward outer extremities.

Dorsals approximately equal in size and similar in shape; anterior margins strongly sloping; posterior margins weakly convex or nearly straight, recurving a little basally in young specimens but hardly so in adults; apex rounded narrowly; base a little less than $^3/_4$ (about 70 %) as long as anterior margin; vertical height a little less than length of base. Origin of first dorsal anterior to rear tips of pelvics by a distance about $^2/_3$ as long as base of first dorsal in young and in mature females; its position relative to tips of pelvics not known for mature males. Interspace between dorsals about $^4/_5$ as long as base of first dorsal in adults but only about half as long in young. Interspace between second dorsal and caudal varying from $^2/_3$ to about as long as base of second dorsal. Caudal ovoid, its lower-posterior margin forming a continuous curve without interrupting corner; upper margin less strongly convex; tip well rounded in small specimens

but somewhat more pointed in large; axis slightly raised; depth below tip of axis a little less than height above it; its length nearly as great as distance from origin of first dorsal to rear end of base of second dorsal. Pelvics conspicuously thick and fleshy, their origin either about opposite termination of pectorals or a little anterior; anterior margins nearly straight; outer corners broadly and evenly arcuate; outer margins ranging from nearly straight to slightly concave when fins are fully spread, but more or less wrinkled or even folded transversely when relaxed in what appears to be the more natural position; inner margins of pelvics attached to sides of tail to extreme tips in both sexes by loose skin posterior to last radial cartilage; extreme length of pelvic, origin to tip, about half as great as breadth of disc, or a little less. Claspers of male originating a little anterior to posterior limit of pelvics and a little inward from outer pelvic margin.

Electric organs more or less apparent externally (when viewed from below), the honeycomb structure showing through overlying skin; 200–220 columns in each organ of specimen 430 mm long.

Color. Upper surface a delicate fawn color, clouded more or less with darker and paler and sometimes with a few small white spots irregularly distributed, shading to paler fawn or whitish along margins of disc, around spiracles, on sides of anterior part of tail and on upper parts of dorsals. Lower surface pure white or with pale yellowish or brownish tinge. After many years of preservation, a specimen from the continental slope is light ochre brown and but little paler below.

Size. The length at birth is less than 81–87 mm (smallest trawled by us off Cuba), the maximum recorded length (type specimen) 490 mm ($19^{5}/_{16}$ in.). The size at which the two sexes mature is not known.

Developmental Stages. Embryos have not been seen.

Habits. This species is known only from depths ranging from 150 fathoms (young) down to 504 fathoms (adults) and at temperatures from as low as 5.5–8° C (42–46° F) on the continental slope of the southeastern United States to higher than 11°C (52° F) off Cuba. Presumably it lives on or near the bottom. Part of the leg of a small crustacean is the only recognizable object that was found among the partially digested stomach contents of two Cuban specimens.

Range. Continental slope off South Carolina and Florida at 350–503 fathoms; off the north coast of Cuba, where young specimens appear to be generally distributed along the zone between the 150–200 fathom and 350 fathom contours (taken at 24 stations out of a total of 166).[179]

Synonyms and References:

Benthobatis marcida Bean and Weed, Proc. U. S. nat. Mus., *36*, 1909: 677 (descr., meas., ill., color, size, Albatross Sta. on continental slope off mid-Florida, 504 fath.); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 295 (descr. after Bean and Weed, 1909).

179. 103 trawl hauls off northern Cuba at depths greater than 351 fathoms failed to yield any specimens, large or small, though adults are known to descend to depths a little greater than 500 fathoms off the southeastern United States.

Benthobatis cervina Bean and Weed, Proc. U. S. nat. Mus., *36*, 1909: 679 (descr., color, meas., size, cf. *B. moresbyi* Alcock; continental slope off N. Florida, 373 fath.); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 295 (descr. after Bean and Weed, 1909).

Suborder RAJOIDEA

Skates and Their Immediate Relatives

Characters. Head and body anterior to axils of pectorals strongly flattened dorsoventrally. Snout neither produced as a long flat blade nor with lateral teeth; anterior sides of head without separate fin-like expansions of pectorals. Tail sharply marked off from body sector; moderately slender in most cases but extremely so exceptionally; with or without dermal folds along its sides. Pectorals united with sides of head nearly or quite to tip of snout, the whole forming a thin flat disc ranging in shape from subcircular to more or less rhomboidal. Two dorsal fins, with cartilaginous rays,[1] exceptionally one or none; first much closer to tip of tail than to tips of pelvics. Caudal reduced to a small membranous fold, sometimes lacking in adults. Outer margins of pelvics more or less concave or notched, weakly so in some but so deeply so in others that anterior division of fin forms a separate limb-like structure; inner margins of pelvics either free or attached to sides of tail to their tips. Teeth numerous, rounded, or with conical cusp. Pelvis approximately straight. a prepelvic spur at each corner.

Upper surface of disc more or less rough with prickles or thorns in most cases, but perfectly smooth in some.

Front of cranium with a single unbranched rostral process, or none; antorbital cartilages not extending forward to help support anterior part of disc; tips of branchial rays not expanded as rounded plates. Pectoral, pelvic and dorsal fins without horny rays (ceratotrichia), the cartilaginous radials extending outward to margins; caudal membrane without radial supports. Surfaces of gill arches, inward from gill filaments, either smooth or with minute fleshy knobs. Spiracle with vestiges of gill folds.

Families. The great majority of the members of this extensive suborder so closely resemble one another that they are united by common consent in a single family, the Rajidae, typical Skates. However, three genera depart from the typically rajid conformation. Two of these, *Anacanthobatis* and *Springeria*, differ in that they have: a perfectly smooth upper surface, no dorsal fins, pelvics attached to sides of tail nearly or quite to their tips, whip-like tail with membranous caudal, and snout produced at the tip as a soft filament; the other, *Arhynchobatis*, differs in having only a single dorsal fin and a caudal that is larger than that of any other Skate.[2] These features seem important enough to warrant the institution of the family Anacanthobatidae for the reception of *Anacanthobatis* and *Springeria* and of the family Arhynchobatidae for *Arhynchobatis*, but with the reservation that the need for the latter would vanish should it prove that the single known specimen of its type genus was abnormal as regards the number of dorsal fins.

1. The type specimen of *Raja garmani* has three dorsals, an interesting reduplicative abnormality (p. 204).
2. See Waite (Rec. Canterbury [N. Z.] Mus., *1* [2], 1909: 150, pl. 20) and Whitley (Fish. Aust., *1*, 1940: 192, fig. 221) for description and photograph of the unique specimen of *Arynchobatis asperrimus* Waite.

Key to Families

1a. Two dorsal fins. Rajidae, p. 133.

1b. Only one dorsal fin, or none.

2a. One dorsal fin; disc prickly; inner margins of pelvics separate from tail. Arhynchobatidae. New Zealand.[3]

2b. No dorsal fin; disc without prickles or thorns; inner margins of pelvics fused with tail nearly or quite to their tips. Anacanthobatidae, p. 327.

Family RAJIDAE

Characters. Tail only moderately slender, at most not more than about 2.0 times as long as body sector; rounded above, flattened below, with a narrow dermal fold along each side. Two dorsal fins. Pelvics with outer margins ranging from only weakly concave to so deeply so that anterior division of fin forms a limb-like structure entirely detached from the posterior part, three-jointed and (as it seems) separately movable. Orbits prominent, rising considerably above general level of head. Eye in some with expanded velum above the pupil. Spiracle close behind eye. Nostrils more or less oblique, their inner ends actually separate from mouth though superficially connected with outer corners of latter by shallow furrows; their expanded inner (anterior) margins joined across a broad isthmus in front of mouth and expanded rearward on either side as an extensive rounded curtain, smooth or more or less deeply fringed, roofing all but outer (anterior) ends of nasal apertures and reaching back to either corner of mouth; posterior margin of outer (exposed) part of nostril also expanded as a narrower flap, smooth-edged in some species but more or less deeply fringed in others, capable of assuming a more or less ring-like or tubular form, depending on the state of concentration. Mouth moderately broad, transverse, its median sector more or less bowed. Teeth numerous, flattish to rounded or with one sharp cusp; arranged either in quincunx or in looser transverse series; several rows in function simultaneously. Skin of upper surface of disc and tail more or less rough with small prickles, larger thorn-like denticles, or both, but without serrate tail spines; lower surface either smooth or with prickly areas, in some cases with a few thorns. Pectoral girdle with a scapular element fused with the upper side of vertebral column. Pelvis nearly straight transversely, with a longer or shorter process extending forward from the outer corner at each end (Fig. 27A). Front of cranium with or without a rostral projection (rostral cartilage), the midline of snout stiffer or softer accordingly.[4] Anterior rays of pectorals either close together at tip of snout (when rostral cartilage is short or lacking) or separated there by rostral cartilage. Characters otherwise those of the suborder (p. 132).

3. *Arhynchobatis* Waite 1909 is placed by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 333) as a subfamily (Arhynchobatinae) of Platyrhinidae, which we refer here to the Rhinobatidae (p. 47). It is described (Waite, Rec. Canterbury [N. Z.] Mus., *1* [2], 1909: 150, pl. 20) as not having a rostral cartilage and its resemblance in this respect to *Psammobatis* among Rajidae is pointed out.

4. For a general account of the head skeleton and comparison with other batoids, see Holmgren (Acta Zool. Stockh., *22*, 1941: 52, 64, 65).

Sex Characters. On the dorsal side of the outer part of each pectoral, adult males have from one to five rows of claw-like "alar" spines, retractile in grooves of the skin. It is supposed that they play some role in holding the female during copulation, but just how is not known. Also, in some species, either in female alone or in both sexes when mature, there may be a belt of large, nonretractile, so-called "malar" thorns on the outer anterior parts of the disc, between the anterior ends of the pectoral rays and the level of the spiracles. Furthermore, large thorns or bucklers are usually much

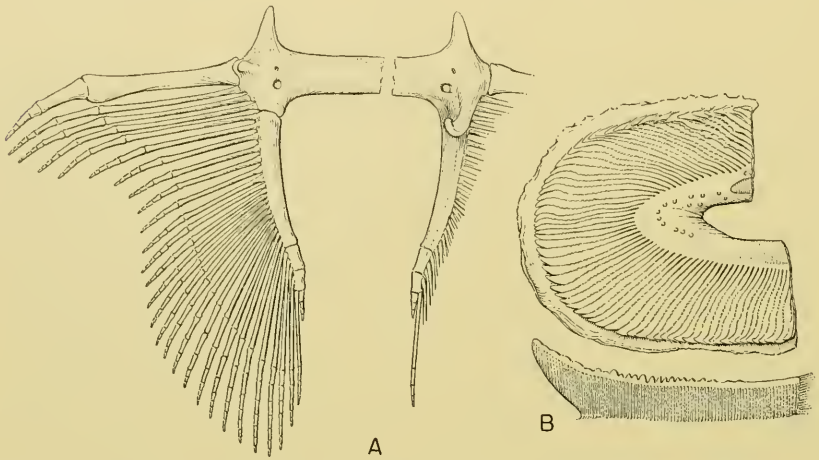

FIGURE 27. *A* Pelvis of *Raja ocellata*, female, about 790 mm long, from Waquoit, Massachusetts (Harv. Mus. Comp. Zool., No. 359); dorsal view on right; about 0.5×. *B* Gill arch (above) and lateral view of gill fold (below) of *Raja laevis*, from off Nantucket Island (Harv. Mus. Comp. Zool., No. 36691), about 0.8×.

more highly developed or more numerous in adult females than in adult males; the latter are the smoother in general. The degree to which the anterior margins of the disc are concave in outline also differs in the two sexes in some species.

Development is oviparous in all rajids in which it is known and doubtless in all other members of the family as well. The egg cases are quadrate with thick horny shells, their corners prolonged as long flexible horns (see also p. 141).

The claspers[5] are cylindrical, narrowing gradually from base toward tip in early stages of growth but becoming more or less dilated terminally with the approach of sexual maturity, at which time they extend considerably beyond the tips of the pelvic fins. The seminal groove along the outer face of the clasper is wide open for a con-

5. For recent accounts of the claspers in various European Skates, see Jungersen (Danish Ingolf Exped., *2* [2], 1898: 56, pl. 4, figs. 45–57; pl. 6, figs. 67, 68), Huber (Zool. Anz., *32*, 1901: 717), and Leigh-Sharpe (J. Morph., *34*, 1920: 260; *36*, 1922: 236, 242, fig. 19), who shows the claspers of *Raja blanda* when relaxed and distended; he also gives brief descriptions of various other European species (J. Morph., *39*, 1924: 567–577).

siderable distance at the anterior end[6] for the reception of the sperm and at the terminal end for its emergence.[7] Along the midsector of the groove, however, one of the edges overlaps the other, the two being held so closely in contact by the scroll-like form of the supporting cartilages that the channel is to all intents a closed tube although its edges are not actually fused. The supporting structures consist of: (a) two or more short basal joints that connect with the tip of the metapterygial cartilage of the pelvic fin; (b) an axial cartilage extending throughout most of the length of the clasper; (c) two narrow lateral cartilages (right and left) that develop along the outer face of the axial cartilage, to enclose the seminal groove as maturity approaches; and (d) three or more terminal cartilages, more or less movable, which vary in number and shape from species to species and which are often extremely complex; one or more of them may have spine-like or blade-like tips or edges. These terminal cartilages, which model the overlying tissues, often throw open the terminal section of the seminal channel, thus exposing the inner walls and a complex pattern of ridges and pockets; undoubtedly this is a function associated with copulation. The function of the cutting structures has been the subject of speculation into which we need not enter here.

Genera. One of the species that belongs here is set apart from all others, indeed from all other known batoids, by the conspicuous fact that several of the middle rays of each of its pectorals are elongated so as to form a narrow spatulate lobe (Fig. 77). It formed the basis of the genus *Dactylobatus* Bean and Weed 1909, which commonly has been accepted. The remaining members of the family, i. e., those of normal skate-like outlines, are divisible into two rather sharply defined groups according to the structure of the pelvics.

A. The margins of the pelvics are so deeply notched as to give the anterior division the form of a slender subcylindrical limb which is entirely separate externally from the posterior division of the fin and which arises independently from the lower surface of the disc some distance in from the edge of the latter. This specialization is also accompanied by interesting skeletal modifications (described on p. 314). Four species are known within this group, all of them referable to the genus *Cruriraja* Bigelow and Schroeder 1948 (p. 313).

B. The anterior and posterior portions of the pelvics are continuous externally one with the other, as is usual among batoids, though the outer margin may be so deeply concave that the fin is definitely bilobed. This group includes all of the numerous members of the family that remain. Its representatives can be distributed among three subdivisions:

1. Those in which the rostral projection from the front of the cranium (rostral cartilage) extends at least as far as the tips of the anterior rays of the pectoral fins and nearly to the extreme tip of the snout.

2. Those in which the rostral projection is so reduced that its tip falls short of the tips of the anterior rays of the pectoral fins, and shorter still of the tip of the snout.

3. Those in which there is no cartilaginous rostral projection from the cranium,

6. The "apopyle" of Leigh-Sharpe.

7. The "hypopyle" of Leigh-Sharpe.

the snout being supported solely by the anterior pectoral rays, assisted more or less by strands or sheets of ligamentous tissue that extend forward from the anterior face of the cranium.[8]

The members of Group 1 (i. e., those with long rostral cartilage and with pelvics and pectorals of the usual rajid shapes) are so many, and those from different seas so closely resemble one another in many cases, that it would be a boon to the student of fishes if this group could be subdivided generically by any criteria that would be easy to see or feel and still be sharply alternative. Various suggestions have been put forward, as is reflected in the considerable number of generic synonyms listed on p. 138 under the genus *Raja*. But all the characters that have been tested (such as length and shape of snout, dermal armature, relative position of dorsal fins on tail, presence or absence of caudal fin-membrane, and structure of the claspers of adult males) intergrade so completely that there seems no escape from the necessity of uniting all in the old genus *Raja* Linnaeus 1758.

The members of Group 2, possessing a well developed rostral cartilage which falls short of the tips of the inner radial cartilages of the pectorals, are grouped together as the genus *Breviraja* Bigelow and Schroeder 1948.

The members of Group 3 (i. e., those in which the rostral projection from the cranium is altogether lacking or only faintly indicated) have at one time or another been distributed among four genera, *Sympterygia* Müller and Henle 1841,[9] *Psammobatis* Günther 1870,[10] *Malacorhina* Garman 1877,[11] and *Irolita* Whitley 1931.[12] It has been pointed out already that *Malacorhina* is not separable from *Psammobatis*,[13] which appears to apply equally to *Irolita*.

Our examination of available material,[14] combined with published accounts and illustrations, lead to the conclusion that *Psammobatis*,[15] which has the outer margins of the pelvics deeply concave and hence definitely bilobed (Fig. 28 A), probably can

8. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 369, pl. 68, fig. 3) characterizes the sheets of tissue that extend forward from the cranium between the pectoral rays of the two sides in the oldest named member of the genus (*Sympterygia* Müller and Henle 1841) as "semi-cartilaginous." But it is more correctly described as "ligamentous" in the specimen he dissected, since it consists of a series of longitudinal bands, as is true of other representatives of the group that we have examined.
9. Plagiost., 1841: 155.
10. Cat. Fish. Brit. Mus., *8*, 1870: 470. Whitley (Rec. Aust. Mus., *18*, 1931: 97) has pointed out that *Psammobatis* Günther 1870 is antedated by *Psammobates*, proposed by Fitzinger (Ann. Wiener Mus., *1* [1], 1835: 113) for reptiles. But the use of it is permissible for Rays, according to the International Code of Zoological Nomenclature, just as the use of *Mustelus* Link 1790 as a generic name for Sharks is permissible, although it was long antedated by *Mustela* Linnaeus 1758, for mammals.
11. Proc. Boston Soc. nat. Hist., *19*, 1877: 203.
12. Rec. Aust. Mus., *18*, 1931: 97.
13. Regan (Rep. Brit. Antarc. Exped., Zool., *1* [1], 1941: 22); and Norman (Discovery Rep., *16*, 1937: 33).
14. Three females, 222–720 mm long, seemingly referable to *Sympterygia bonaparti* Müller and Henle 1841, from Uruguay and northern Argentina; one male, 505 mm long, and one female, 530 mm, of *S. acuta* Garman 1877, from Argentina; two females, about 475 and 560 mm long, of *Raja microps* Günther 1880, from Argentina; and one small male, about 190 mm long, of *R. scobina* Philippi 1857, from the vicinity of Montevideo; all the foregoing in U. S. National Museum; likewise the dissected specimens on which Garman based his illustrations of *Sympterygia acuta* Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 68, figs. 3, 4) and of *Malacorhina mira* Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 69, figs. 1, 2).
15. Type species *Psammobatis rudis* Günther equals *Raja scobina* Philippi 1857.

be retained as generically distinct from *Sympterygia*,[16] in which these margins are so slightly concave that the fins, when spread, can hardly be characterized as bilobed (Fig. 28 B). This course is followed in the accompanying Key (p. 138), but with the reservation that future study, especially a more critical comparison of species that have been described recently from Peru, may prove that a complete gradation exists between these extremes.[17]

FIGURE 28. *A* Pelvic fins of *Psammobatis scobina*, female, from Uruguay (U. S. Nat. Mus., No. 86721). *B* Pelvic fins of *Sympterygia microps*, female, from Buenos Aires, Argentina (U. S. Nat. Mus., No. 55579). Each about 0.5×.

Key to Genera

1a. Middle rays of each pectoral prolonged as a narrow spatulate process (Fig. 77).
Dactylobatus Bean and Weed 1909, p. 323.

1b. Middle rays of each pectora not prolonged as a narrow spatulate process.

2a. Anterior subdivision of pelvic fin forming a slender limb-like structure, entirely separate externally from posterior subdivision of fin, arising from lower surface of disc some little distance inward from edge of latter.
Cruriraja Bigelow and Schroeder 1948, p. 313.

2b. Anterior subdivision of pelvic fin continuous externally with posterior subdivision, not a separate limb.

3a. Front of cranium with a definite conical rostral projection (rostral cartilage), longer or shorter.

4a. Tip of rostral cartilage extending forward beyond extremities of pectoral rays to tip of snout, or nearly so. *Raja* Linnaeus 1758, p. 138.

4b. Tip of rostral cartilage falling short of extremities of pectoral rays and of tip of snout.
Breviraja Bigelow and Schroeder 1948, p. 284.

16. Type species *Sympterygia bonaparti* Müller and Henle 1841.

17. See Norman (Discovery Rep., *16*, 1937: 28) for a general synopsis of species referred by him to *Psammobatis*, and Hildebrand (Bull. U. S. nat. Mus., 189, 1946: 52) for a Key to Peruvian species, with accounts of four described as new.

3b. Rostral projection from front of cranium lacking or only faintly indicated; anterior part of disc supported chiefly by anterior rays of pectorals more or less assisted by ligamentous bands extending forward from front of cranium.

5a. Outer margins of pelvics deeply concave or notched, the fins definitely bilobed, even when spread wide (Fig. 28A).

Psammobatis Günther 1870.
Western South Atlantic from Cape Frio (Lat. 22°56′ S) near Rio de Janeiro southward to Straits of Magellan; Chile, Peru, and vicinity of Cocos I. (Lat. 4°50′ N);[18] also southern Australia.

5b. Outer margins of pelvics weakly concave, the fins not definitely bilobed when spread wide (Fig. 28B).

Sympterygia Müller and Henle 1841.
Argentina, Chile, Peru; perhaps Ecuador also.[19]

Genus *Raja* Linnaeus 1758

Raja Linnaeus, Syst. Nat., *1*, 1758: 231; type species, *R. clavata* Linnaeus 1758. European seas, designated by Jordan and Gilbert (Proc. U. S. nat. Mus., *5*, 1882: 36).

Generic Synonyms:

Raia Scopoli, Introd. Hist. Nat., 1777: 464; emended spelling for *Raja* Linnaeus 1758.
Dipturus Rafinesque, Caratt. Gen. Spec. Sicil., 1810: 16; type species, *Raja batis* Linnaeus 1758. European seas.
Cephaleuthcrus Rafinesque, Indice Ittiol. Sicil., 1810: 48, 61; type species, *C. maculatus* Rafinesque. Sicily.[20]
Platopterus Rafinesque, An. Nature, 1815: 93; proposed to replace *Raja* Linnaeus 1758.
Dasybatus Blainville, Bull. Soc. philom. Paris, 1816: 112; type species, *Raja clavata* Linnaeus 1758.[21]
Propterygia Otto, Nova Acta Acad. Leop.-Carol., *10*, 1821: 112; type species, *P. hypostícta* Otto.[22] Scotland near Edinburgh.
Dasybatis Blainville, in Vieillot, Faune Franç., Poiss., 1825: 12; type species, *Raja batis* Linnaeus 1758. European seas; designated by Jordan (Genera Fish., *1*, 1917: 134).[23]
Uraptera Müller and Henle, S. B. Akad. Wiss. Berlin, 1837: 117; also Arch. Naturg., (Jahrg. 3) *1*, 1837: 400; generic diagnosis but no species named; type species, *U. agassizii* Müller and Henle (Plagiost., 1841: 155, pl. 50). Brazil.
Laevirajia Bonaparte, Nuov. Ann. Sci. Nat. Bologna, *2*, 1838: 203; type species, *Raja oxyrincha* Linnaeus 1758. Mediterranean and European seas.

18. *Psammobatis spinosissimus* Beebe and Tee-Van 1941 (Zoologica N. Y., *26*, 1941: 259), described from vicinity of Cocos Island.
19. Reported by Tortonese (Boll. Mus. Zool. Anat. comp. Torino, [3] *47* [89], 1939: 48), but the description is not sufficient for judgement as to specific identity. The type species *Sympterygia bonaparti* Müller and Henle 1841 was without locality.
20. Based on an abnormal Skate in which the anterior extensions of the pectorals had remained separate from the sides of the head after birth. Similar monstrosities have been described subsequently under other names, as noted below.
21. *Raja batis* Linnaeus 1758 was designated as type by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 355). But *batis* was not among Blainville's list of 22 species, so we propose that *R. clavata* replace it, since it was among his species.
22. As Müller and Henle (Charlesworth Mag. Nat. Hist., 2, 1838: 90, footnote) pointed out long ago, the specimen described and pictured by Otto was a monstrosity of the same sort that had been named *Cephaleutherus* earlier by Rafinesque 1810, the anterior part of each of its pectorals forming a narrow ear-like lobe that suggests the cephalic fins of the Devil Rays (Mobulidae). Similar malformations have been reported from time to time. Couch (Fish. Brit. Isles, *1*, 1867: 96) pictures one with a secondary pectoral lobe on the one side but not on the other.
23. Jordan credits this genus to De Serville. However, the section on fishes in Faune Francaise seems to have been by Blainville. For dates of publication, see Sherborn and Woodward (Ann. Mag. nat. Hist., [7] *8*, 1901: 493).

Propleygia Müller and Henle, Charlesworth Mag. Nat. Hist., *2*, 1838: 90, footnote; equals *Propterygia* Otto 1821.

Laeviraja Bonaparte, Icon. Fauna Ital., *3* Fasc. 23, 1839: in descr. of *L. oxyrychus*, pl. not numbered; equivalent to *Laevirajia* Bonaparte 1838.

Batis Bonaparte, Mem. Soc. Neuchâtel Sci. Nat., *2*, 1839: 7, extra; type species, *Raja radula* Delaroche 1809. Balearic Isles, Mediterranean. Not *Batis* Boie 1833, for birds.

Hieroptera Fleming, New philos. J. Edinb., *31*, 1841: 236, pl. 4; type species, *H. abredonensis* Fleming. Scotland.[24]

Actinobatis Agassiz, L., Poiss. Foss., *3*, 1843: 372; type species, *Raia ornata* Agassiz, a fossil.

Eleutherocephalus Agassiz, L., Nom. Zool. Pisc., 1846: 71, Index, 136; substituted for *Cephaleutherus* Rafinesque 1810.

Perioptera Gistel, Naturg. Tier., 1848: X; *nomen nudum*; perhaps a misspelling for *Hieroptera* Fleming 1841. Not seen.

Peroptera Gistel, Naturg. Tier., 1848: X; same as *Perioptera* Gistel 1848. Not seen.

Amblyraja Malm, Göteborgs och Bohuslans Fauna, 1877: 607; type species, *Raia radiata* Donovan 1807. Northern Great Britain.

Leucoraja Malm, Göteborgs och Bohuslans Fauna, 1877: 609; type species, *Raja fullonica* Linnaeus 1758. European seas.

Alpharaia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 568; type species, "*Raja circularis*, the Cuckoo Ray."[25]

Betaraia Leigh-Sharpe, J. Morph., *39*, 1924: 568; type species, *Raja clavata* Linnaeus 1758. European seas.

Gammaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 571; type species, *Raja batis* Linnaeus 1758. European seas.

Deltaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 573; type species, *Raia radiata* Donovan 1807. Northern Great Britain.

Epsilonraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 574; type species, *Raja platana* Günther 1880. Estuary of Rio de la Plata.

Zetaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 575; type species, *Raja brachyura* Günther 1880. Straits of Magellan and westward.

Etaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 576; type species, *Raja murrayi* Günther. Kerguelen I.

Thetaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 577; type species, *Raja eatonii* Günther 1876. Kerguelen I.

Iotaraia Leigh-Sharpe, J. Morph., *39*, 1924: 567, 577; type species, *Raja marginata* Lacépède 1802–1803. France and England.

Spiniraja (subgenus) Whitley, Aust. Zool., *9*, 1939: 251; type species, *Raja* (*Spiniraja*) *ogilbyi* Whitley. Australia.[26]

Zearaja Whitley, Aust. Zool., *9*, 1939: 254; type species, *Raja nasuta* Müller and Henle 1841. New Zealand.

Pavoraja Whitley, Aust. Zool., *9*, 1939: 254; type species, *Raja nitida* Günther 1880. New South Wales.

Rioraja Whitley, Aust. Zool., *9*, 1939: 254; proposed in substitution for *Uraptera* Müller and Henle 1837, preoccupied by Billberg, 1820, for Lepidoptera.

Dentiraja (subgenus) Whitley, Fish. Aust., 1, 1940: 184; type species, *Raja dentata* Klunzinger 1872.

Argoraja (subgenus) Whitley, Fish. Aust., 1, 1940: 190; type species, *Raja polyommata* Ogilby 1910.

Generic Characters. Disc subquadrangular to rhomboid, the snout ranging from short and obtuse to long and more pointed. Tail with a narrow ribband-like longitudinal

24. A monstrosity similar to those described earlier under the generic names *Cephaleutherus* Rafinesque 1810 and *Propterygia* Otto 1821.

25. "Cuckoo" is the common name for *Raja naevus* Müller and Henle 1841, not for *Raja circularis* Couch 1838. Therefore it is doubtful which of these two species Leigh-Sharpe had in mind. For the history of *R. circularis*, see Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 37). Leigh-Sharpe proposed the names *Alpharaia, Betaraia, Gammaraia, Deltaraia, Epsilonraia, Zetaraia, Etaraia, Thetaraia* and *Iotaraia* as "Pseudogenera"; but this term has no nomenclatural standing.

26. *Spiniraja* is characterized as differing "from true *Raja* in being very spiny above and below." But no spines are indicated on Whitley's subsequent illustration (Fish. Aust., 1, 1940: 186) of its lower surface; hence we cannot judge whether it is actually any rougher below than are some species of typical *Raja*. Nor do we see any characters to separate Whitley's genera *Zearaja* and *Pavoraja*, proposed without generic diagnoses (Aust. Zool., *9*, 1939: 254), or his subgenera *Dentiraja* and *Argoraja* (Fish. Aust., 1, 1940: 184, 190).

fold along either side. Pectorals of ordinary form, without spatula-like lateral process; outer posterior corners more or less broadly rounded, their posterior outlines definitely recurved before their junction with the sides of the trunk, the fin thus having a distinct inner posterior margin; pectorals overlapping pelvics somewhat in most cases. Two dorsal fins.[27] Caudal reduced to a narrow finfold, sometimes lacking in adults. Outer margins of pelvics more or less concave but not cut deeply enough to separate anterior from posterior section of fin. Eyes with upper part of pupil covered by a dark fleshy veil or velum, with crenulate margin that can be expanded or contracted (controls amount of light entering pupil). Nostrils strongly oblique. Teeth either closely crowded in quincunx arrangement or more loosely spaced in transverse series; rounded in most females, cuspidate in mature males, and both sexes of some species[28] with sharp cusp. Upper surface of disc with prickles or larger thorns, or both. Anterior margin of cranium with a distinct rostral projection (rostral cartilage) reaching nearly or quite to tip of snout, extending at least as far as extremities of pectoral rays or farther (see discussion p. 135). Anterior lobe of pelvic supported by three radials articulated along posterior bar of pelvic arch, followed without intervening gap by first 2–4 radials borne along anterior part of basipterygial cartilage.

Young Skates at hatching are already so much like the adult in form that they are recognizable as to species, at least in most cases (for an exception, see p. 148; Key alternative 7b). However, they may differ more or less from their parents in form of disc, in details of spination, and in possessing a somewhat longer tail. There is only one juvenile character that calls for special mention here, and that is the persistence for some little time after hatching of a greater or lesser part of the long caudal filament that is characteristic of embryo Skates in general during late embryonic stages. Different species, and possibly different individuals even within a given species, appear to differ in this respect. Consequently, the length of the tail to the origin of one or the other of the two dorsal fins is a more dependable character for diagnostic purposes than is the tail's total length.

The electric organs, of species for which they are known, are slender spindle-shaped masses along the sides of the tail, extending nearly the entire length of the latter in some species but shorter in others. They also vary in thickness from bulky, occupying practically the entire space between the skin and the vertebral column, to much narrower and separated from the vertebral column by a thick muscular layer. In some species the electric elements consist of columns of discs at right angles to the longitudinal axis of the tail, whereas in others they are small club- or cup-shaped bodies with a longer or shorter tail-like prolongation. They have a rich blood supply and are innervated with innumerable fibrils which are derived from spinal rather than cranial

27. Abnormalities in this respect have been described; see under *R. garmani*, p. 204, footnote 14.
28. The alteration that takes place in the shape of the teeth in males of many species at sexual maturity results from the replacement of the older rows by younger ones, not from any alteration in the shape of the teeth present earlier. Examination of specimens approaching maturity also shows that this replacement takes place a little earlier in the upper jaw than in the lower.

nerves as in the Electric Rays. Their embryonic derivation is from the caudolateral musculature.[29]

In one set of observations, shocks of about one-half volt were recorded instrumentally per centimeter of length of organ.[30] But we find no recorded instance of a fisherman reporting a shock from any Skates of this genus, though many thousands of them are handled yearly; nor have we ever felt the least sensation from grasping the tail of a Skate other than the rather unpleasant one of being wounded by the thorns.

Size. The various species of the genus *Raja* of the western North Atlantic range in length from about $1^1/_2$ to about 5 feet, perhaps to as much as 6 feet, and in weight from about a pound to perhaps 50–60 pounds (p. 223). The females, at least in most cases, are larger than the males, often by as much as one-third.

Developmental Stages. In the commercial catches in British waters the females considerably outnumber the males. This disparity appears to result from the fact that the two sexes are more or less segregated, the gravid females apparently congregating in more compact bodies or schools than the males.[31]

Skates are described as mating ventral side to ventral side, and pairs so engaged are sometimes hauled up on hook and line. It has been observed[32] that the males and females of one of the larger European species (*R. batis*) hold their discs flat while mating; but the female of the smaller *R. asterias* curves her pectorals ventrally, while the male, rolling the outer corners of his pectorals out of the way ventrally, then bends the fins inward around her back, which brings his alar spines in position to fasten to her.

At least for some of the larger species it is reported that only one clasper is introduced into the cloaca of the female at a time, but for other species it is said that both are introduced simultaneously.[33]

Just after copulation the claspers are much swollen and reddened by suffused blood.[34]

Experiments[35] have proved that the egg is fertilized just before its capsule is formed around it. The process by which the sperm is introduced into the oviduct has not been traced for any Skate or Ray, but according to Clark the female apparently can lay a series of eggs fertilized by sperm from one act of coition. Completion of the egg capsules and extrusion of the egg appears to follow shortly after fertilization.

Egg capsules of Skates are horny or leathery in texture, ranging in color from light auburn to dark brown or even black. The shell, composed of a substance resem-

29. For a detailed account of the electric elements and their development in various Skates, see especially Ewart (Philos. Trans., [B] *179*, 1888: 399–416, pls. 66–68; 1889: 539–552, pls. 79–80).
30. See Sanderson and Gotch (J. Physiol., *9*, 1888: 141) for a detailed account of these experiments and of the general nature of the electric discharges.
31. For summary of available evidence on this point, see Steven (J. Mar. biol. Ass. U. K., *18*, 1933: 611).
32. See Le Danois (Vie et Moeurs Poiss., Payot, Paris, 1949: 199, text figs. 55, 56) for an eye-witness account and illustrations of mating pairs of *Raja batis* and of *R. asterias*.
33. Fowler (Rep. N. J. Mus. [1905], 1906: 730) quotes an eye-witness account of a pair of *Raja eglanteria* harpooned while in the act of coition, the male with both claspers inserted.
34. See Leigh-Sharpe (J. Morph., *36*, 1922: 242, fig. 10) for illustration of clasper of *Raja blanda*, relaxed and distended.
35. Clark, J. Mar. biol. Ass. U. K., *12*, 1922: 584.

bling keratin[36] and constructed of several fibrous layers, becomes more brittle on exposure to sea water. The body of the capsule is quadrate in shape and the four corners are drawn out in long tubular horns, which taper to filamentous tips in some species but which are blunter in others, the pair at one end being considerably longer than those at the other. As a rule each horn has a slit-like opening on the outer side which is closed in early stages either by a plug of albumen or by a delicate membrane. Later the albumen is absorbed, leaving the slits open. Also, in some species the lateral margins of the capsule are keeled or fringed, and in most species (perhaps all) the margins, sometimes the sides as well, bear series of silky and sticky filaments; these mat into felt-like masses that serve to anchor the egg to algae, pebbles or other objects on the bottom. Before they are laid, the egg capsules lie with the longer pair of horns directed toward the cloaca and with the more convex face of the capsule toward the dorsal side of the mother.

It appears that osmosis, which takes place through the shell and by which equilibrium is maintained with the surrounding sea water[37] provides the necessary oxygen for the embryo at first. The means by which the aeration of the embryo is accomplished after the albumen has been absorbed has been the subject of controversy. However, recent experiments seem to have confirmed the old view that sea water passes in and out through the slits on the horns of the capsule after they have opened, thus supplementing the effects of osmosis through the shell in providing the necessary intake of oxygen and outgo of carbon dioxide.[38]

Observations in aquaria have shown that the eggs of at least some species are laid in pairs, one soon after the other, with a rest period of one to five days before the deposition of another pair. A single female may produce eggs during a period of several months, in spring, summer, or fall. For example, one female of the European *Raja brachyura* Lafont 1873 laid 25 capsules at irregular intervals during a 49-day period (April 12 to May 31) in the aquarium at Plymouth, England. It has been observed also that the egg capsules in aquaria are buried in the sand. In most cases the capsules that have been dredged from the sea bottom have been firmly fastened to masses of broken shells, fragments of algae, gravel, sand, etc., and Skate eggs in the Plymouth Aquarium have been seen to adhere to objects of this sort immediately after they were laid. Under aquarium conditions, the incubation period for six common European species averaged from $4^1/_2$ to about $14^3/_4$ months.

Normally, the embryo lies within the capsule with its head pointing diagonally toward the longer pair of horns, its pectorals folded over onto the dorsal surface and its tail curled forward over its back. At hatching it emerges through a transverse slit between the two longer horns,[39] and the empty capsules, popularly called mermaids' or sailors' purses, are familiar objects along the seashore.

36. Its chemical composition was determined by Hussak and Welker (J. biol. Chem., *4*, 1908: XLIV–XLV).
37. This maintenance of equilibrium was demonstrated by Peyréga (Bull. Soc. zool. Fr., *39*, 1914: 211).
38. See Clark (J. Mar. biol. Ass. U. K., *12*, 1922: 584) for an account of these experiments, with summary of older observations on the aeration of the Skate embryo.
39. See Clark (J. Mar. biol. Ass. U. K., *12*, 1922: 582–591) for an interesting account of the egg capsule, egg laying,

The embryonic Skate is more shark-like than batoid in its general appearance during the early stages of development; it is slender, with its pectorals and pelvics still represented only by a pair of short rounded lobes on either side and with one or two anal fin-folds besides the dorsals. The external branchial filaments, developed on the second to sixth gill arches, are a prominent feature of its general aspect at this stage, and the tip of its tail is drawn out as an attenuated filament, longer or shorter. The enormous development of the pectorals that finally leads to the "Skate" form commences while the external branchial filaments are still persistent and continues until after they have disappeared. The fusion of the pectorals with the sides of the head is normally completed some time prior to birth; however, abnormal specimens are sometimes encountered in which the anterior part of one pectoral or the other, or both, continues separate from the head after birth and probably throughout life, as described elsewhere (p. 261). The yolk is entirely drawn within the abdomen some little time previous to hatching, and the abdomens of late embryos are commonly much swollen with it. Newly hatched Skates resemble their parents in general shape, except as noted (p. 140), and they hold as strictly to the bottom as the older ones.

Habits and Food. Typically, Skates are ground fish, often lying partially buried. When alarmed, a Skate will usually press down against the bottom instead of dashing away, and the colors of their backs blend so closely with the background that they are as difficult to detect as any member of the flounder tribe. But they often rise some distance above the bottom in pursuit of prey, and occasionally a Skate may be seen at the surface, seemingly basking in the sun.

They are most plentiful on smooth, sandy, gravelly bottoms, or on mixtures of sand and broken shells; they are found much less frequently on soft mud (see also p. 262). To find a Skate among rocks or on ledges is an unusual event, though we have occasionally seen them there.

Observations of Skates in aquaria[40] show that they are mostly inactive by day, lying quietly on bottom, often so much buried in sand up to the eyes, spiracles, and ridge of the back that their outlines are not to be seen. But they swim actively by day if disturbed, and after swimming they return to the bottom either by swimming or simply by sinking. To bury themselves they stir the sand by movements of their pectorals, thus allowing it to fall back upon them.

They advance by gently undulating the margins of the wing-like pectorals as described previously (p. 8); the tail, if used at all, serves only as a rudder and often drags on bottom, leaving a trail behind it. They swim rather slowly unless violently disturbed, when they can advance with astonishing speed.

Skates are strictly carnivorous and feed mostly at night. The diet for such species as have been studied consists chiefly of crabs and shrimps, lobsters, smaller crustacea such as amphipods, isopods, mysids, and various polychaete worms. They also eat

fertilization, duration of incubation, and other aspects of the early life history of several of the more common British Skates.

40. Schmitlein, Mitt. Zool. Stat. Neapel., *1*, 1878: 9.

bivalve mollusks, small fish of various kinds, and cephalopods of the less active sorts.[41] Occasionally pieces of eel grass (*Zostera*) or algae, even pebbles, are found in the stomach of a Skate, no doubt taken accidentally with its living prey.

A Skate cannot capture active animals by direct attack because of the ventral position of its mouth, so it swims over its victim by a sudden dart forward and settles down upon it, thus preventing its escape. In fact, in the English Channel, Skates sometimes feed almost exclusively on fishes, especially herring.[42]

In the case of at least some of the European species (e. g., *Raja clavata*), the young are hatched in shallow water, after which they gradually disperse to greater depths as they grow. Some of them also carry out feeding migrations on a considerable scale,[43] but no precise information is available in this respect for any of the western Atlantic Skates.

Numerical Abundance. Skates may be extremely numerous locally on suitable bottoms in temperate and boreal latitudes. In northern Europe, where they are valued for human food, their abundance is reflected in the considerable landings in various countries,[44] for example, about 92,100,000 pounds in 1937, and 92,400,000 pounds in 1936, which is equivalent to about 18–46 million individuals, assuming the average weight per Skate to be about 2–5 pounds.

Statistics of the commercial catch in North America do not afford comparable information for the western Atlantic, for most of the Skates are thrown back. In 1940 the total landings reported for the entire Atlantic seaboard of the United States amounted to only 373,000 pounds, in 1944 to 501,300 pounds. But Skates are far more plentiful than the foregoing might suggest. Average catches of about one Skate to 33 fish of all kinds on long lines have been reported at various localities in the Gulf of Maine.[45] And an average of perhaps 120–150 Skates per square mile in 37 hauls of an otter trawl on Georges Bank (equivalent to about one Skate per four acres of bottom fished) probably far understates the actual numbers present, for the trawl, equipped with large wooden rollers, doubtless passed over many Skates that were lying on the bottom, while others probably escaped the nets as the latter approached them.

Skates are also abundant from southern New England to New Jersey on sandy bottoms. Old records for a pound net on the shore of Nantucket Sound,[46] operated during the season of 1871 chiefly for clupeoids and therefore not particularly well placed for ground fish, show that more Skates (2,923) than flatfishes of all kinds combined (2,714) were taken. A more recent report states that not less than 10,000 pounds of Skates, weighing 1–5 pounds, were discarded from one lift of a pound net at Bradleys

41. On the northeastern coast of the United States, as at Woods Hole, Massachusetts, pieces of squid have often been found in Skates' stomachs, although these were probably captured by the latter while in the pound nets or in fish traps in which the Skates were taken. According to information furnished by the Bingham Oceanographic Laboratory, whole squid have been found in Skates caught in otter trawls.

42. Steven, J. Mar. biol. Ass. U. K., *18*, 1932: 23–24.

43. Steven, J. Mar. biol. Ass. U. K., *18*, 1932: 18.

44. England, Scotland, Eire, France, Germany, Holland, Norway, Sweden, Poland, Iceland.

45. Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 57; Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324.

46. At Waquoit, Mass. (Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: table 1).

Beach, New Jersey.[47] On the other hand, they are so much less abundant on soft bottom that on one occasion in the Gulf of Maine we took only one Skate for every 250–300 fish of other kinds.[48] Unfortunately, there are no statistics available as to the numbers of Skates taken along our Middle Atlantic Coast southward from New Jersey or in their southern center of occurrence off southern Brazil, Uruguay, and Argentina.

Relation to Man. In northern Europe during 1936 and 1937 the average market price to the fisherman was about 4–5 cents per pound, the total value of Skates sold being about £1,050,000 and £926,000 or $5,100,000 and $4,500,000, respectively. But in North American markets the demand for Skates is very small; according to the reported total landings for 1944, only about 501,000 pounds, worth about $18,000, were sold along the Atlantic Coast of the United States (including Chesapeake Bay), about 310,000 pounds, worth about $3,000,[49] along the Pacific Coast. Small numbers have been used from time to time as fertilizer, as fresh manure, and as bait for lobster traps along the New England Coast. But the vast majority of those caught along the Atlantic coasts of Canada and the United States are thrown back.

Depth Range. Skates are most abundant in depths less than 100 fathoms, many of them occurring plentifully in shallow water, a few right up to the tideline. Stray Skates have even been taken in rivers so far in from the mouth that they had doubtless been in fresh water for a longer or shorter time.[50] But there is no conclusive evidence that any member of the genus exists permanently in fresh water. On the other hand, several of the species that are common in 30–60 fathoms also range down the slopes to depths of 200–300 fathoms or deeper. There is a considerable list of species that are known only from depths greater than 100 fathoms, some of these being from depths greater than 200 fathoms while others have been recorded from depths greater than 800–1,500 fathoms.[51] However, we doubt whether any Skate can be classed as a typical member of the abyssal fauna, although two (*R. abyssicola* Gilbert 1893, from the offing of British Columbia, and *R. badia* Garman 1899, from the Gulf of Panama) have been reported from depths greater than 1,200 fathoms, knowledge of each being confined

47. On July 8, 1892 (Smith, Bull. U. S. Fish Comm., *12*, 1894: 368).

48. For details of catches totaling about 11,900 fish of all species, see Bigelow and Schroeder (Biol. Bull. Woods Hole, *76*, 1939: 322).

49. Statist. Dig. U. S. Fish Wildl. Serv., *16*, Fish. Statist. U. S. (1944), 1948.

50. A large Skate was taken many years ago in the River Ouse near Bedford, England, some 60–70 miles from the sea (Pascoe, Zoologist, [3] *7*, 1883: 506). More recently one has been reported from the Yangtze in China (Tchang, Science Shanghai, *14*, 1929: 398–407). A Skate has been reported also from fresh water of the Rio de la Plata (Eigenmann, Rep. Princeton Exped. Patagonia, Zool., *3* [2], 1909: 377; Smith, H. W., Biol. Rev. [Cambridge], *11*, 1936: 11). But the specimen in question (*Raja platana* Günther, Challenger Rep., Zool., *1*, 1880: 12, CHALLENGER Sta. 321) was actually taken off Montevideo; i. e., in salt water where the dredge also yielded a rich catch of various marine invertebrates. We might point out in passing that Eigenmann's reference of *Raja microps* Günther 1880 (actually referable to the closely related genus *Psammobatis*) to fresh water rests on the capture of a specimen at that same station.

51. *Raja badia* Garman 1899, from 1,270 fathoms, Pacific off Panama; *R. abyssicola* Gilbert 1893, 1,588 fathoms, off British Columbia; *R. fyllae* Lütken 1887, down to 983 fathoms, northeastern Atlantic; *R. hyperborea* Collett 1878, down to 1,309 fathoms, N. Atlantic; *R. reversa* Lloyd 1906, 820 fathoms, northern part of Arabian Sea; *R. trachura* Gilbert 1892, 822 fathoms, off southern California; *R. jenseni* Bigelow and Schroeder 1949, 991 and 1,043 fathoms, off southern New England; *R. bathyphila* Holt and Byrne 1908, 835–1,188 fathoms, continental slope between offings of Chesapeake Bay and Nova Scotia; and *R. mollis* Bigelow and Schroeder 1949, 858 fathoms, off southern Nova Scotia.

to the original capture; it is possible, therefore, that both of them may occur in lesser depths as well.

Range. Skates are most numerous, both as to species and individuals, in warm temperate and boreal latitudes along the two sides of the Atlantic and Pacific oceans, both north and south, and they occur in some variety in the subarctic belts of both hemispheres. A number of species are known also around Cuba, from the warm waters of the northern part of the Indian Ocean (including the Gulf of Aden and Arabian Sea), the Philippines and East Indies, Formosa, Queensland, the west coast of Central America and northern South America. But none seem to have been reported from the Micronesian, Polynesian, or Hawaiian Islands in the Pacific or from the American side of the tropical Atlantic between Yucatán and mid-Brazil. From the equatorial coast of West Africa, anywhere between Cape Verde and Walfish Bay,[52] we find but a single record of the genus. And it is hardly conceivable that they would not have been reported frequently in scientific literature if they occurred within these extensive areas in numbers at all approaching the Skate populations that exist off the coasts of Europe, off the eastern United States and Canada, or from southern Brazil southward.

An interesting aspect of distribution is found in at least four pairs of species; the members of each pair are so closely allied that they may prove indistinguishable, yet each pair has one member confined to the temperate-boreal latitudes in the northern hemisphere while the other is found in the corresponding latitudinal belt in the southern hemisphere. These pairs are: *R. batis* Linnaeus 1758 of the northeastern Atlantic and a Skate that has been reported as *R. batis* from South Africa;[53] *R. alba* Lacépède 1803 from the northeastern Atlantic and a form that has been reported from South Africa under that same name; *R. radiata* Donovan 1807 of the northern North Atlantic and *R. doello-juradoi* Pozzi 1935 from Argentina and the Patagonian-Falkland Islands region; and *R. spinicauda* Jensen 1914 of the subarctic North Atlantic and *R. griseocauda* Norman 1937 of the Patagonian-Falkland Islands region. Similar cases of bitemperate, biboreal, or bipolar distribution are known among Sharks of the genera *Carcharias* (Sand Sharks), *Lamna* (Mackerel Sharks), *Cetorhinus* (Basking Sharks), *Squalus* (Spiny Dogfishes), and *Somniosus* (Greenland Shark and a subantarctic counterpart).

Species. Raja includes a greater number of species by far than any other genus of elasmobranchs. The named forms from various parts of the world that are recognized in recent synopses of the genus approximate 95–100. While critical comparisons may be expected to result in the union of some species that are now regarded as separate,[54] reductions in the total number from this cause are likely to be more than counterbalanced by the ultimate discovery of new species, especially down the slopes of the continents.

The numerical distribution of *Raja* species as known at the present time is approximately as follows: Common to the two sides of the North Atlantic in high latitudes,

52. *R. maderensis* Lowe 1837, reported from Dahomey by Osorio (J. Sci. math. phys. nat. Lisboa, [2] *3*, 1895: 253).
53. See Norman (Discovery Rep., *12*, 1935: 37) for a recent revision of South African species of *Raja*.
54. A comparison of the Skates from the two sides of the northern North Pacific is especially needed.

4; peculiar to the western North Atlantic, south to Yucatán, 16; peculiar to the eastern North Atlantic and Mediterranean south to the Canaries, Morocco, and equatorial South Africa, 18; common to the western North Atlantic and western South Atlantic, poleward from about Lat. 40° S, 2; common to the eastern North Atlantic and South Africa, 2;[55] peculiar to the western South Atlantic, from mid-Brazil southward to Falkland Islands and Straits of Magellan, and southern Chile, 15; South Georgia, 1; South African region, 7;[56] common to east and west sides of northern North Pacific in high latitudes, including Bering Sea, 5; Alaska to Lower California, 8; Pacific Coast of Central America to Ecuador, 3; western North Pacific, Sea of Okhotsk to Formosa and southern China, 12; Australia, Tasmania, and New Zealand, 8; East Indies, northern Indian Ocean, Arabian Sea, and Gulf of Aden, 6; Kerguelen Island and subantarctic Indian Ocean, 2.[57]

Generally, the specific identification of Skates has been regarded as difficult for anyone not thoroughly conversant with the group, primarily because some of the characters that have been stressed in published accounts (because the most obvious)[58] do not lend themselves easily to precise definition or are subject to variation with age and sex. Also, a character that is constant in one species may show considerable variation in another. But our examination of considerable collections to which we have had access has convinced us that the various species differ so definitely from each other—though often in less obvious ways—that specific identification calls only for precise observation of characters readily seen, felt, measured, or counted.

Lack of adequate study material from other parts of the world has prevented us from extending the accompanying Key to Species (p. 147) beyond the confines of the western North Atlantic. On the other hand, it has seemed wise to expand it to include local species of *Breviraja* as well as *Raja*, because generic identification of one or the other is difficult in some cases without x-ray photographs to show the level at which the tip of the rostral cartilage terminates relative to the anterior rays of the pectorals. A Provisional Key to western South Atlantic Species of *Raja* is included (p. 153) as a convenience.

Key to Western North Atlantic Species of *Raja* and *Breviraja*[58a]

1a. Mucous pores on lower surface of disc conspicuously marked by black dots or lines (Fig. 47 B). *Raja laevis* Mitchill 1817, p. 217.

1b. Mucous pores on lower surface of disc not marked by black dots or lines.

2a. No conspicuous thorns on tail or on disc posterior to pectoral girdle; rostral projection from cranium soft and flexible from base to tip. *Raja mollis* Bigelow and Schroeder 1950, p. 237.

55. But see p. 146. 56. From recent synopsis by Norman (Discovery Rep., *12*, 1935: 38).

57. *R. eatonii* Günther 1876 and *R. murrayi* Günther 1880. See Norman (Rep. Brit. Antarct. Exped. [1929-1931], [B] *1* [2], 1937: 67; and Discovery Rep., *18*, 1938: 100).

58. Examples are the precise outlines and degree of concavity of the anterior margins of the pectorals, the anterior angle of the disc, the length of the tail relative to the body, and the degree of spininess of the disc.

58a. Based on specimens examined.

2b. Tail or disc posterior to pectoral girdle, or both, with few or many conspicuous thorns; rostral projection from cranium firm, whether short or long.

3a. Distance from origin of second dorsal to level of axils of pelvics longer than distance from level of axils of pelvics to tip of snout by an amount at least as great as distance between nostrils, or greater.

4a. Either the tail with dark crossbars or the dorsal fins conspicuously blackish, or both.

5a. Upper surface of disc plain-colored; tail without dark crossbars.

Breviraja atripinna Bigelow and Schroeder 1950, p. 286.

5b. Upper surface of disc with dark markings; tail with dark crossbars.

6a. Thorns on shoulders (2–4), along midline of disc, and on anterior part of tail, large and conspicuous; anterior margin of anterior lobe of pelvics as long as distance from origin of pelvics to rear tip, or longer.

Breviraja plutonia (Garman) 1881, p. 297.

6b. Thorns on shoulders (0–2), along midline of disc, and on tail, small and inconspicuous; anterior margin of anterior lobe of pelvics shorter than distance from origin of pelvics to rear tip.

Breviraja cubensis Bigelow and Schroeder 1950, p. 293.

4b. Neither the tail with definite dark crossbars nor the dorsal fins blackish.

7a. Midbelt of tail with 3–4 rows of conspicuous thorns.

Breviraja sinus-mexicanus Bigelow and Schroeder 1950, p. 302.

7b. Midbelt of tail with only a single median row of thorns.

Raja fyllae[59] Lütken 1887; newborn, p. 194.

Raja senta[59] Garman 1885; newborn, p. 264.

3b. Distance from origin of second dorsal to level of axils of pelvics little if any longer than distance from level of axils of pelvics to tip of snout, and in most cases considerably shorter.

8a. Tip of firm rostral cartilage terminating considerably posterior to tip of snout (Fig. 62).[60]

9a. Midzone of disc posterior to scapular region with only one or two inconspicuous thorns, if any, in midline.

Breviraja colesi Bigelow and Schroeder 1948, p. 289.

9b. Midzone of disc posterior to scapular region with two to several rows of thorns.

10a. Snout anterior to orbits not more than about twice as

59. It may be difficult in some cases to distinguish newborn specimens of *R. fyllae* and *R. senta* from each other. See under Distinctive Characters, pp. 194–266.

60. The point at which the rostral cartilage ends can be felt, if not seen, for all the species included under 8a.

long as distance between orbits; first and second dorsal fins confluent, without interspace; dorsal surface of disc not freckled with many small dark dots.

Breviraja spinosa Bigelow and Schroeder 1950, p. 306.

10b. Snout anterior to orbits about 3.3 times as long as distance between orbits; first and second dorsal fins separated by a definite (though short) interspace with one thorn; upper surface of disc closely freckled with small dark brown dots.

Breviraja yucatanensis Bigelow and Schroeder 1950, p. 310.

8b. Firm rostral cartilage reaching nearly to extreme tip of snout.

11a. No large thorns on posterior $^1/_4$–$^1/_3$ of tail.

Raja senta Garman 1885, p. 264.[61]

11b. One or more rows of thorns along posterior part of tail as well as farther forward along it.

12a. No large thorns anywhere on disc between nuchal region and level of axils of pectorals, except for alar spines of sexually mature males.

13a. Upper surface of pectorals smooth, without prickles.

14a. First and second dorsals confluent.

Raja teevani Bigelow and Schroeder 1951, p. 276.

14b. First and second dorsals separated by a definite interspace.

15a. Lower surface with a band of prickles along anterior edge of disc and along rostral cartilage; distance between dorsals about as long as base of first dorsal; outer margin of nostril lobe fringed.

Raja olseni Bigelow and Schroeder 1951, p. 251.

15b. Lower surface smooth everywhere; distance between dorsals less than half as long as base of first dorsal; outer margin of nostril lobe smooth.

Raja laevis Mitchill 1817; newly hatched, p. 217.

13b. Upper surface of pectorals rough with close-set prickles except along outer margins.

Raja spinicauda Jensen 1914, p. 271.

61. Newly born *R. senta* may have thorns on the posterior part of the tail, and thus fall under alternative 7b; see p. 266, footnote 138.

12b. Disc between nuchal region and level of axils of pectorals with more or fewer large thorns in addition to alar spines of mature males.

16a. Distance from origin of first dorsal to axils of pelvics at least as long as distance from axils of pelvics to fronts of orbits, or longer.

17a. Lower surface of disc and tail uniform brown, darker than upper surface.

Raja bathyphila Holt and Byrne 1908, p. 159.

17b. Lower surface of disc and of tail paler than upper surface, either uniformly whitish, gray, or fawn-colored, or with dusky markings.

18a. First and second dorsals confluent.

Raja fyllae Lütken 1887; half-grown and adults, p. 194.

18b. First and second dorsals separated by a short but definite interspace.

19a. Upper surface of disc densely though irregularly strewn with small dark freckles.

Raja lentiginosa Bigelow and Schroeder 1951, p. 228.

19b. Upper surface of disc with dark freckles mostly concentrated in a few conspicuous rosettes.

Raja garmani Whitley 1939, p. 200.

16b. Distance from origin of first dorsal to axils of pelvics hardly longer than distance from axils of pelvics to rear margins of orbits, and in most cases considerably shorter.[62]

20a. Only one row of large thorns along tail; if more than one, those of median row much larger and more conspicuous than the others.

21a. Not more than 19 large thorns along midline of back and tail between nuchal region and first dorsal fin.

Raja radiata Donovan 1807, p. 255.

21b. At least 24 large thorns along midline of back and tail between nuchal region and first dorsal fin.

62. On some very young specimens of *Raja erinacea* the distance from the axils of the pelvics to the origin of the first dorsal fin is a little longer than the distance from the axils of the pelvics to the rear margins of the orbits (Fig. 37).

22a. Tail posterior to tips of pelvics with a lateral row of smaller thorns on either side in addition to the larger median row; at least 34 large thorns in young and up to 50 or more in adults in median row from nuchal region to first dorsal fin.

Raja lintea Fries 1838, p. 232.

22b. Tail with only one (the median) row of large thorns; not more than 26–31 thorns in median row from nuchal region to first dorsal fin.

23a. Upper teeth in only about 44 series; adults with large thorns on posterior parts of pectorals and on outer anterior parts of disc.

Raja hyperborea Collett 1878, p. 206.

23b. Upper teeth in at least 55 series; adults without large thorns on posterior parts of pectorals or on outer anterior parts of disc.

Raja jenseni Bigelow and Schroeder 1950, p. 213.

20b. More than one row of large thorns along tail; no one row much more conspicuous than the others.

24a. Three or more rows of thorns along midbelt of disc between shoulders and level of axils of pectorals; first and second dorsal fins confluent or only narrowly separated, without intervening thorns.

25a. Upper teeth in at least 72^{63} series, most often 90–100; does not

63. Bigelow and Schroeder (Bull. U. S. Bur. Fish., *48*, 1936: 324) gave as few as 70. While re-examination of the particular specimens on which this count was based showed that the number should have been stated as 80, W. Templeman reports to us the capture of one from the Grand Bank of Newfoundland with only $\frac{72}{74}$ teeth.

mature sexually until at least 26 inches long.

Raja ocellata Mitchill 1815, p. 240.

25b. Upper teeth in not more than 66 series, usually less than 54; matures when only 18–20 inches long.

Raja erinacea Mitchill 1825, p. 176.

24b. Only one row of thorns along midbelt of disc between shoulders and level of axils of pectorals; first and second dorsal fins separated by a definite interspace or by one or more thorns.

26a. Upper surface of each pectoral marked with a conspicuous dark-centered ocellar spot, much larger than any other of the dark markings.

27a. Lateral margins of snout rather deeply concave (Fig. 60); horizontal diameter of eye only about $^1/_5$ as long as snout anterior to orbits.

Raja texana Chandler 1921, p. 279.

27b. Lateral margins of snout hardly concave; horizontal diameter of eye about $^1/_3$ as long as snout anterior to orbits.

Raja ackleyi Garman 1881, p. 155.

26b. Upper surface of each pectoral not marked with a large and prominent ocellar spot; surface of disc as a whole with many irregular dark dots and narrow bars, transverse or oblique.

Raja eglanteria Lacépède 1802, p. 165.

Provisional Key to Western South Atlantic Species of *Raja*[64]

1a. Distance from origin of first dorsal fin to tip of tail as long as distance from origin of first dorsal to tips of pelvic fins, or longer.

agassizii Müller and Henle 1841.
Rio de Janeiro.

1b. Distance from origin of first dorsal fin to tip of tail considerably shorter than distance from origin of first dorsal to tips of pelvic fins.

2a. Lower surface of disc with many conspicuous black dots and streaks marking the mucous pores.

3a. Inner part of each pectoral fin marked with one large and conspicuous pale-centered ocellar spot. *cyclophora* Regan 1903.
Rio de Janeiro.

3b. Each pectoral not marked with a large ocellar spot, or, if present, indistinct.

4a. Distance from axils of pelvics to rear end of second dorsal fin only about $^2/_3$ as long as distance from axils of pelvics to rear margins of orbits; distance from origin of first dorsal to tip of tail considerably shorter than that from level of rear margins of orbits to tip of snout; mucous pores on upper surface of anterior part of disc not marked by black dots or streaks. *flavirostris* Philippi 1892.
Patagonian-Falkland Islands region, Straits of Magellan, and Chile.

4b. Distance from axils of pelvics to rear end of second dorsal as long as distance from axils of pelvics to rear margins of spiracles, or longer; distance from origin of first dorsal to tip of tail about as long as distance from level of rear margins of orbits to tip of snout; upper surface of anterior part of disc with black spots and streaks, marking mucous pores.

5a. Tail with three rows of thorns; margins of orbits and scapular regions also with thorns; snout anterior to orbits only about as long as distance between outer margins of orbits.
castelnaui Ribeiro 1904.
Vicinity of Rio de Janeiro.

5b. Tail with only one row of thorns; no thorns around orbits or on scapular regions; snout anterior to orbits about 1.5 times as long as distance between outer margins of orbits.

64. See Ribeiro (Arch. Mus. nac. Rio de J., *14*, 1907: 177–179; Fauna brasil., Peixes, *2* [1] Fasc. 1, 1923: 33–36) for descriptions and illustrations of Brazilian species and Norman (Discovery Rep., *16*, 1937: 12–47) for those of the Patagonian-Falkland Islands region and Straits of Magellan. The Brazilian Skate reported by Ribeiro, first as *Raja erinacea* Mitchill (Arch. Mus. Nac. Rio de J., *14*, 1907: 176) and subsequently as *R. cirrifera* Regan (Fauna brasil. Peixes, 2 [1], Fasc. 1, 1923: 33), and by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 356) as a new species, *R. extenta*, is a *Psammobatis* (see Norman, Discovery Rep., *16*, 1936: 28).

platana Günther 1880.
Rio de Janeiro[65] and mouth of La Plata River.

2b. Lower surface of disc not marked with black dots or streaks.
6a. No large thorns anywhere on disc anterior to level of axils of pectorals.
7a. Distance from cloaca to tip of tail shorter than that from cloaca to tip of snout; outer posterior parts of pectorals mostly smooth.
scaphiops Norman 1937.
North of Falkland Islands.
7b. Distance from cloaca to tip of tail longer than distance from cloaca to tip of snout; outer posterior parts of pectorals with extensive prickly areas. *griseocauda* Norman 1937.
Patagonian-Falklands region.
6b. Disc anterior to level of axils of pectorals with conspicuous thorns either along midline, around orbits, on scapular regions, or on all three parts.
8a. No thorns on scapular regions.
9a. Tail with only one row of thorns.
10a. Snout in front of orbits at least four times as long as distance between orbits; anterior margins of disc deeply concave. *echinorhyncha* Ribeiro 1923.
Rio de Janeiro.
10b. Snout in front of orbits not more than 2.5 times as long as distance between orbits; anterior margins of disc not deeply concave.
11a. Disc with many small rounded white spots; thorns on tail noticeably larger than those along mid-dorsal line on disc. *albomaculata* Norman 1937.
Patagonian-Falklands region.
11b. Disc not marked with many small white spots; thorns on tail not larger than those on midline of disc.
brachyurops Fowler 1910.
Northern Argentina (?); Patagonian-Falklands region.
9b. Tail with two lateral rows of thorns along each side in addition to median row. *brasiliensis* Müller and Henle 1841.
Brazil.
8b. Each scapular region with 1–3 thorns.
12a. Only 12–15 thorns along midline of back and tail from nuchal region to first dorsal fin, all large.
doello-juradoi Pozzi 1935.
Northern Argentina to Patagonian-Falklands region.

65. On re-examination, the specimen from Rio de Janeiro described by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 361) under the name *R. castelnaui* Ribeiro 1904 proves not to be that species; it agrees closely with Günther's account and illustration (Challenger Rep., Zool., *1* [6], 1880: 11, pl. 3) of *R. platana*.

12b. 25–42 moderate-sized thorns along midline of back and tail from nuchal region to first dorsal.

13a. No large thorns on margins of orbits; about 42 thorns in mid-dorsal row. *multispinis* Norman 1937.
Northwest of Falkland Islands.

13b. One thorn at anterior margin and one at posterior margin of each orbit; not more than about 30 thorns in mid-dorsal row.

14a. Inner parts of pectorals roughened with small scattered prickles; only one thorn on each scapular region. *macloviana* Norman 1937.
Patagonian-Falklands region.[66]

14b. Inner parts of pectorals mostly smooth; each scapular region usually with two thorns.
magellanica Steindachner 1903.
Patagonian-Falklands region, and Straits of Magellan.

Raja ackleyi Garman 1881

Ackley's Skate

Figure 29

Study Material. Two specimens, a male 410 mm long, the type (Harv. Mus. Comp. Zool., No. 748) and a female 231 mm long (U. S. Nat. Mus., No. 148290), both taken off Yucatán.

Distinctive Characters. *R. ackleyi* appears to be separated from *R. texana* in that the outer margins of its disc are broadly rounded (rather abrupt in *R. texana*); also, on the average the former has a narrower disc, 1.1–1.2 times as broad as long (1.2–1.35 times for *texana*); and its disc is sprinkled with small light and dark spots with the ocellar spots[67] oval (disc plain brownish with round ocellar spots on *R. texana*).[68] The color pattern in itself is enough to set *R. ackleyi* (and *R. texana*) apart from all other Skates of the western North Atlantic, except for specimens of *R. ocellata* on which there is a single large ocellar spot on each side and on which the other dark markings are not conspicuous. The disc and tail of *R. ocellata* are so much thornier and the anterior contour is so much more obtusely rounded than those of *R. ackleyi* that the two could hardly be confused. *R. cyclophora* Regan 1903,[69] from Brazil, closely parallels *R. ackleyi* (and *R. texana*) in the presence of a single conspicuous ocellar spot on the posterior

66. *R. macloviana* Norman 1937 seems so closely allied to *R. magellanica* Steindachner 1903 that it may prove to represent a variety of the latter.

67. In *R. ackleyi* the distance from the center of the ocellus to the center of the orbit is about 1.0–1.3 times the distance between the centers of the ocelli; in four specimens of *R. texana*, this distance was 0.83–1.0 times.

68. If the two species are finally united, the name *ackleyi* has priority.

69. For an excellent photograph of *R. cyclophora*, see Ribeiro (Arch. Mus. nac. Rio de J., *14*, 1907: pl. 16).

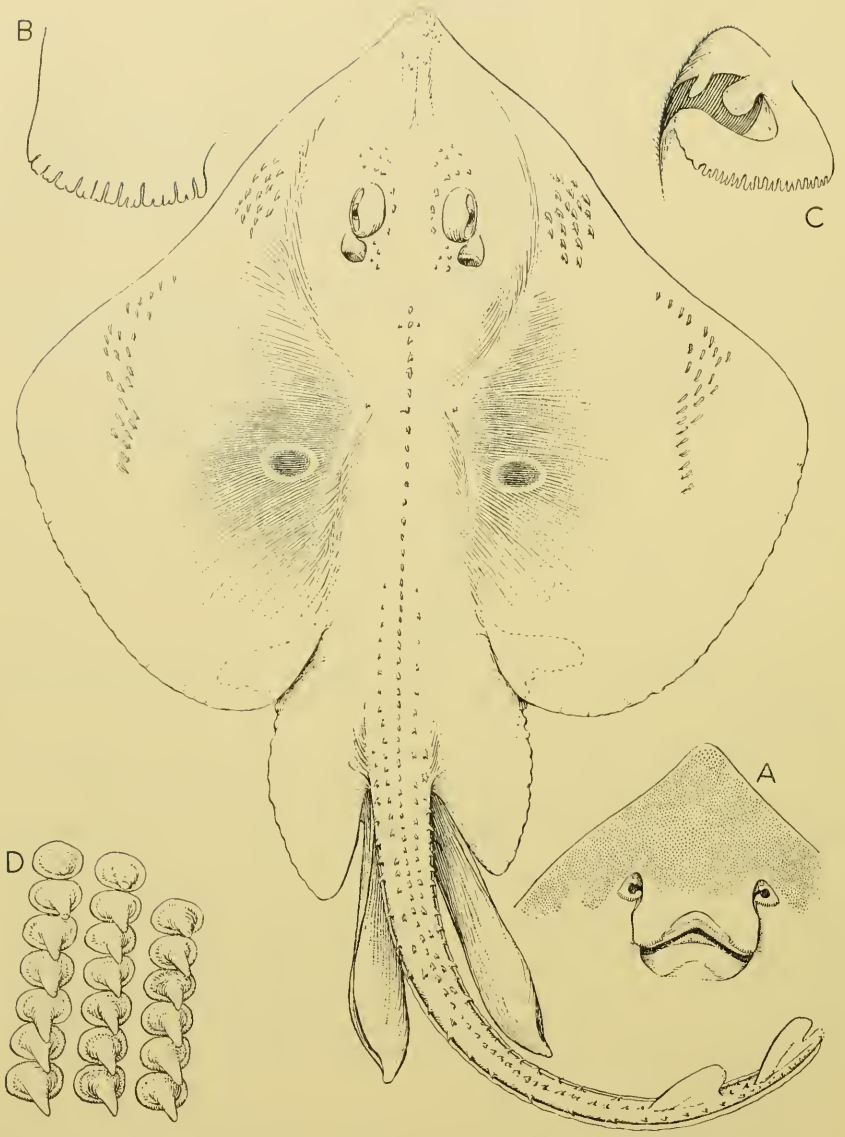

FIGURE 29. *Raja ackleyi*, adult male, 410 mm long, from Yucatán Bank (Harv. Mus. Comp. Zool., No. 748, type). *A* Ventral view of anterior part of head. *B* Posterior margin of nasal curtain, about 3.4×. *C* Outer posterior margin of nostril, about 3.4×. *D* Upper teeth, near middle of mouth, about 12×.

part of each pectoral. But the pectorals of *R. cyclophora* are angular, hence they contrast sharply with the rounded outer contours of *R. ackleyi*.

Description. Proportional dimensions in per cent of total length. Female, 231 mm, from off Yucatán (U. S. Nat. Mus., No. 148290). Male, 410 mm, from Yucatán Bank (Harv. Mus. Comp. Zool., type, No. 748).

Disc: extreme breadth 63.0, 53.7; length 53.5, 48.0.
Snout length: in front of orbits 15.1, 11.6; in front of mouth 17.7, 12.7.
Orbits: horizontal diameter 4.3, 3.7; distance between 4.6, 3.9.
Spiracles: length 2.6, 2.4; distance between 7.0, 5.8.
Mouth: breadth 7.8, 7.5.
Nostrils: distance between inner ends 8.7, 7.5.
Gill openings: lengths, 1st 1.9, 1.7; 3rd 1.9, 1.8; 5th 1.3, 1.2; distance between inner ends, 1st 15.4, 13.0; 5th 8.2, 7.3.
First dorsal fin: vertical height 3.9, 2.2; length of base 7.7, 4.6.
Pelvics: anterior margin 9.5, 10.4.
Distance: from tip of snout to center of cloaca 48.2, 45.8; from center of cloaca to 1st dorsal 31.6, 40.7; to tip of tail 51.8, 54.2.
Interspace between: 1st and 2nd dorsals 4.1, 2.3.

Disc about 1.1–1.2 times as broad as long; maximum anterior angle in front of spiracles 97° on male, 106° on female; anterior rays of pectorals extending about 60–70 % of distance from level of front of orbits toward tip of snout, the latter not appreciably projecting; anterior contour only weakly concave rearward from tip of snout and then a little more deeply so opposite spiracles on male, but less so on female; outer and posterior corners broadly rounded; posterior margins rather strongly convex. Tail with a narrow fold beginning about an eye's length posterior to axil of pelvic on each side and extending to tip; length of tail from center of cloaca to origin of first dorsal 0.7–0.9 times, to origin of second dorsal 0.9–1.0 times, and to tip 1.1–1.2 times as great as distance from center of cloaca to tip of snout.

A cluster of small thorns on tip of snout; an irregular patch in front of spiracle with three or four along its inner edge; one thorn on each shoulder on larger (male) specimen (not yet developed on smaller female); one or two rows of small thorns over anterior part of rostral cartilage; inner edge of orbit with three thorns on smaller specimen, the number increasing to about eight on mature male; midline of back from nuchal region to first dorsal of smaller specimen with 27 thorns, the row interrupted at first between scapular region and level of axils of pectorals but becoming continuous later; thorns of midline increasing to 70–72 at maturity (about 20 anterior to axils of pectorals), the larger roughly alternating with the smaller, decreasing generally in size rearward; on partly grown specimens, each side of tail with one additional irregular row of thorns of various sizes extending rearward from near axil of pelvic to opposite second dorsal; large specimens with two such rows on each side of tail, the uppermost row (developed the latest) extending from a little anterior to axils of

pectorals back to first dorsal and followed by prickles as far as second dorsal; skin of disc and tail naked otherwise except for a few minute prickles opposite orbits and spiracles and along edge of disc on male abreast of alar spines. Adult male with two rows of alar spines;[70] also a patch of about 18 thorns on either side in malar region abreast of eye and spiracle. Lower surface of larger specimen (male) prickly from tip of snout rearward to a little beyond midlevel of nostrils and along margins of disc to level of mouth, but otherwise naked on disc and tail; smaller specimen (female) smooth everywhere below.

Snout in front of orbits about 3.0–3.5 times as long as distance between orbits; about 1.6–2.0 times as long in front of mouth as distance between exposed nostrils. Orbit about 1.5 times as long as spiracle; distance between orbits a little greater than length of orbit. Length of first gill openings about $^1/_4$ as great as width of mouth, the fifth gill openings about 70 % as long as the first; distance between first gills 1.5–1.8 times as long as distance between exposed nostrils; distance between fifth gills about as great as distance between nostrils. Both nasal curtain and expanded posterior (outer) margin of nostril fringed. Mouth a little bowed in adult male, less so in female.

Teeth $^{42}_{44}$ in adult male, in transverse series, with thorn-like and somewhat recurved cusp on circular or oval base, the uppers and lowers alike; $^{48}_{44}$ series in female, arranged in quincunx, the median teeth with low cusp, the outer teeth without cusp.

Dorsal fins about equal in size, with convex anterior margin and well rounded apex; base of first dorsal about 87 % as long as distance between spiracles. Interspace between first and second dorsals about $^1/_2$–$^2/_3$ (50–66 %) as long as base of first dorsal. Pelvics moderately concave outwardly, weakly scalloped; anterior margin about $^5/_8$ as long as distance from pelvic origin to rear tip; anterior lobe narrow, outer margin of posterior lobe weakly convex, rear tip well rounded even in adult male, reaching back about $^1/_3$ the distance from origin of pelvic to tip of tail. Claspers of adult male reaching a little more than halfway from tip of pelvic toward first dorsal fin.

Anterior rays of pectorals reaching about $^3/_5$ the distance from level of fronts of orbits toward tip of snout.

Color. Upper surface pale yellowish brown, sprinkled with small indefinitely outlined darker and lighter spots and pale patches; a dark oval ocellar spot with pale margin on inner part of each pectoral a little posterior to axis of greatest breadth. Lower surface white without dark markings.

Size. The type specimen, a male 410 mm long, appears to be mature sexually.

Developmental Stages. The egg cases have not been seen.

Habits. Nothing is known.

Range. So far known with certainty only from the Yucatán Bank and near there in Lat. 22°08′ N, Long. 86°53′ W, and from southern Florida.[71] Skates have also

70. On this particular specimen there are five alar spines in the outer row on the left-hand side but only two in the outer row on the right-hand side.

71. A third specimen of *R. ackleyi* was sent to us for identification by Stewart Springer. It was a female, 404 mm long, caught off the Dry Tortugas in Lat. 25°03′ N, Long. 82°56′ W, in 25 fathoms, January 19, 1951, Oregon St. 233.

been reported under this same name from tropical West Africa[72] and from the Azores,[72a] but they differed from the typical *ackleyi* in dermal armature and in plain coloration without ocellar spots.

Synonyms and References:

Raja[73] *ackleyi* Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 234 (descr., Yucatán Bank); Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 25; also Mem. Harv. Mus. comp. Zool., *22*, 1896: 25 (descr., after Garman, 1881; Yucatán Bank); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 70 (descr., Yucatán Bank); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, Yucatán Bank); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 336, pl. 19 (descr., ill., Yucatán Bank); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (listed, Yucatán Bank); Beltran, List. Peces Mexicanos, 1934: 5 (listed, Mexico; not seen).

Raja ackleyi (in part) Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 107 (descr., after Garman; but ill. after Goode and Bean and ref. to Azores from Roule, 1912, probably are not for *ackleyi*).

Doubtful References:

Raia[74] *ackleyi* Goode and Bean, Smithson. Contr. Knowl., *31*, 1895: pl. 7, fig. 23; also Mem. Harv. Mus. comp. Zool., *22*, 1896: pl. 7, fig. 23 (ident. doubtful); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (4), 1900: pl. 10, fig. 31 (same ill. as Goode and Bean, 1895: pl. 7, fig. 23); Roule, Bull. Inst. océanogr. Monaco, 254, 1912: 20 (probably not *R. ackleyi* because dermal armature diff. and color plain; Azores).

Raja bathyphila Holt and Byrne 1908

Abyssal Skate

Figures 30, 31

Study Material. Two females and three males, 117–467 mm long, from the lower part of the continental slope between the offings of Chesapeake Bay and southern Nova Scotia, at 835–1,188 fathoms, in U. S. National Museum.[75]

Distinctive Characters. The most convenient field mark for this little known species, and one that separates it from all other Skates known from the North Atlantic except *R. olseni*, is the dark brown color of the lower surface of the disc, which is darker than the upper surface. *R. bathyphila* has been classed (incorrectly in our opinion) as a synonym of the young of *R. lintea* (p. 165), but there is no danger of confusing halfgrown or larger specimens of the two species.[76] The anterior contour of the disc is noticeably different (cf. Figs. 30, 31 with 49); the tail of *R. bathyphila* is much longer relatively, as are the anterior margins of its pelvic fins; the upper surface of its disc is much more prickly generally; and there are only about six large mid-dorsal thorns from pectoral girdle to pelvic girdle on *R. bathyphila* (about twice that many on *R. lintea*). Also, the tail of *R. bathyphila* is thornier, and while it is the sides of the tail low down

72. Poll (Résult. Sci. Exped. oceanogr. Belge Côt. Afr. Atlant. [1948–49], 1951: 144–149.

72a. Roule, Bull. Inst. océanogr. Monaco, 243, 1912: 20.

73. Also spelled *Raia*.

74. Also spelled *Raja*.

75. One specimen each at the following ALBATROSS Sts.: 2206, Lat. 39°35′ N, Long. 71°25′ W, 1,043 fathoms; 2210, Lat. 39°38′ N, Long. 71°19′ W, 991 fathoms; 2691, Lat. 39°37′ N, Long. 71°08′ W, 835 fathoms; 2706, Lat. 41°29′ N, Long. 65°36′ W, 1,188 fathoms; and 2728, Lat. 36°30′ N, Long. 74°33′ W, 859 fathoms.

76. Very young *R. lintea* of proven parentage have not been seen, so far as we can learn.

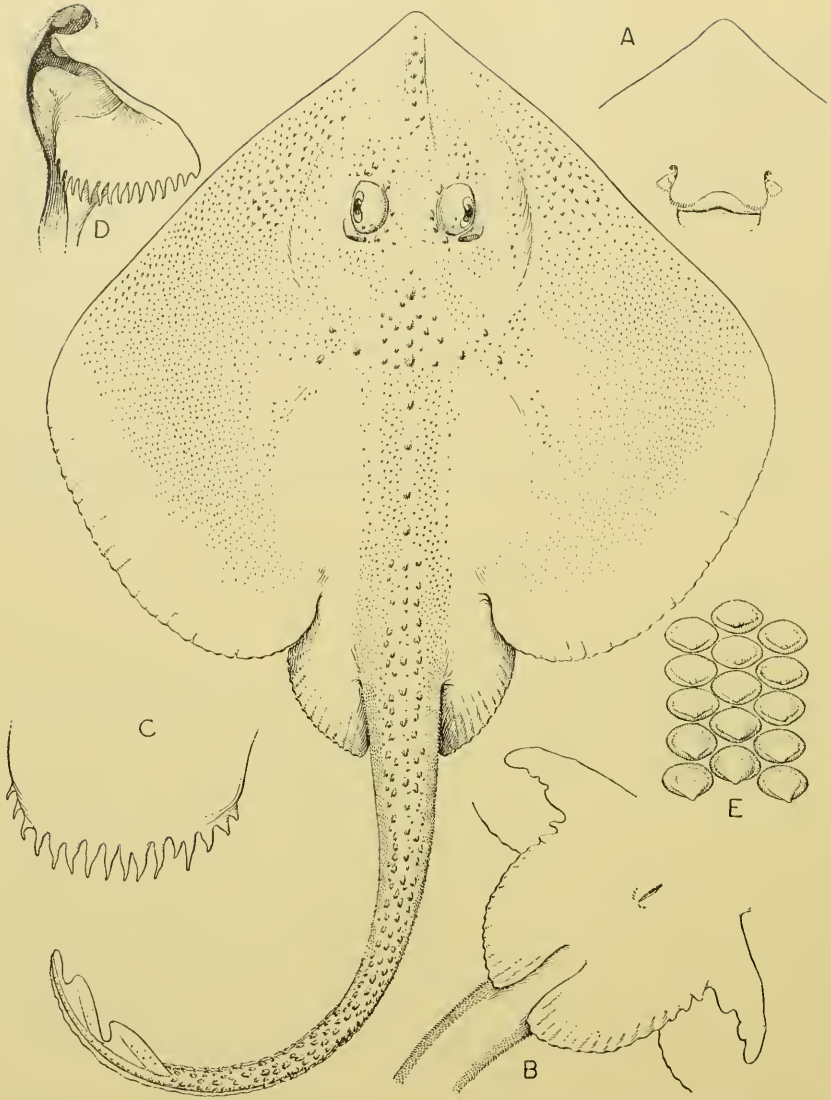

FIGURE 30. *Raja bathyphila*, female, 463 mm long, from lower part of continental slope off southern New England, Lat. 39°38′ N, Long. 71°19′ W, 991 fathoms (U. S. Nat. Mus., No. 35591). *A* Lower surface of anterior part of head with nostrils and mouth. *B* Ventral view of pelvics and base of tail. *C* Posterior margin of nasal curtain, about 3.5×. *D* Left nostril, about 3.5×. *E* Upper teeth, about 6.5×.

that are prickly (in addition to the large thorns) on *R. bathyphila*, it is the upper surface of the tail that is prickly on *R. lintea*. The lower surface of *R. lintea*, though it often exhibits dark markings, seems never to be uniformly dark chocolate as on *R. bathyphila*, except perhaps on some very small specimens.

Actually, *R. bathyphila* more nearly resembles *R. fyllae*, apart from color, but its snout is more acute and relatively longer than that of *R. fyllae*; it has fewer large thorns along the midzone of its disc rearward from the pectoral girdle; and the bands of prickles along the sides of its tail are much denser and more conspicuous.

Among Skates of the Pacific Coast of America, *R. bathyphila* parallels *R. badia* Garman 1899 from the Gulf of Panama, *R. trachura* Gilbert 1892 from California to Alaska, and *R. abyssicola* Gilbert 1895 from off British Columbia in the uniformly dark color of its lower surface and in its abyssal habitat. But the shape of its disc marks it off from *R. badia* (outer corners angular in *badia* and axis of greatest breadth far rearward), and the presence of conspicuous thorns around its eyes and on its scapular regions separates it just as sharply from both *R. trachura* and *R. abyssicola*. *R. bathyphila* has been characterized as "allied to *Raia isotrachys*" Günther 1877,[77] which was taken off Japan by the CHALLENGER in 365 fathoms and which is brownish black below. But the original illustration of the unique specimen of *R. isotrachys* pictures it as resembling *R. badia* more nearly than *R. bathyphila* in shape and as lacking large thorns on the disc.[78] Among the other deep-water Skates of the genus *Raja* from the western Pacific-Indian ocean regions that are wholly or largely dark-colored below,[79] *R. bathyphila* seems closest to *R. mamillidens* Alcock 1889 from the Gulf of Manaar in having a small number of teeth, a generally prickly disc, and large thorns around the orbits, on the scapular regions, and along the midline of the back from the nuchal region posteriorly. But the snout of *R. bathyphila* is relatively much longer and the disc relatively wider than these characters in *R. mamillidens*,[80] while the teeth of the latter are cuspidate even on small females (rounded in *R. bathyphila*) and its color uniformly black below as well as above.

Description. Proportional dimensions in per cent of total length. Male, 328 mm long, from Lat. 41°28′ N, Long. 65°30′ W (U. S. Nat. Mus., No. 148276). Female, 467 mm long, from Lat. 39°38′ N, Long. 71°19′ W (U. S. Nat. Mus., No. 35591).

Disc: extreme breadth 49.4, 52.0; length 43.3, 44.9.

Snout length: in front of orbits 11.3, 12.2; in front of mouth 12.8, 12.4.

Orbits: horizontal diameter 3.6, 3.6; distance between 3.3, 3.2.

Spiracles: length 2.4, 2.6; distance between 6.4, 6.3.

Mouth: breadth 4.9, 5.9.

Nostrils: distance between inner ends 6.4, 6.1.

77. By Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 329.
78. Günther, Challenger Rep., *22*, 1877: pl. 3.
79. For a recent survey of Indo-Pacific rajids, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 357).
80. Length of snout in front of nostrils described as being only about as great as distance between nostrils for *R. mamillidens*, the disc only about as broad as long (Alcock, Ann. Mag. nat. Hist., [6] *4*, 1889: 380; Ill. Zool. Investigator, Fishes, 1892: pl. 8, fig. 1).

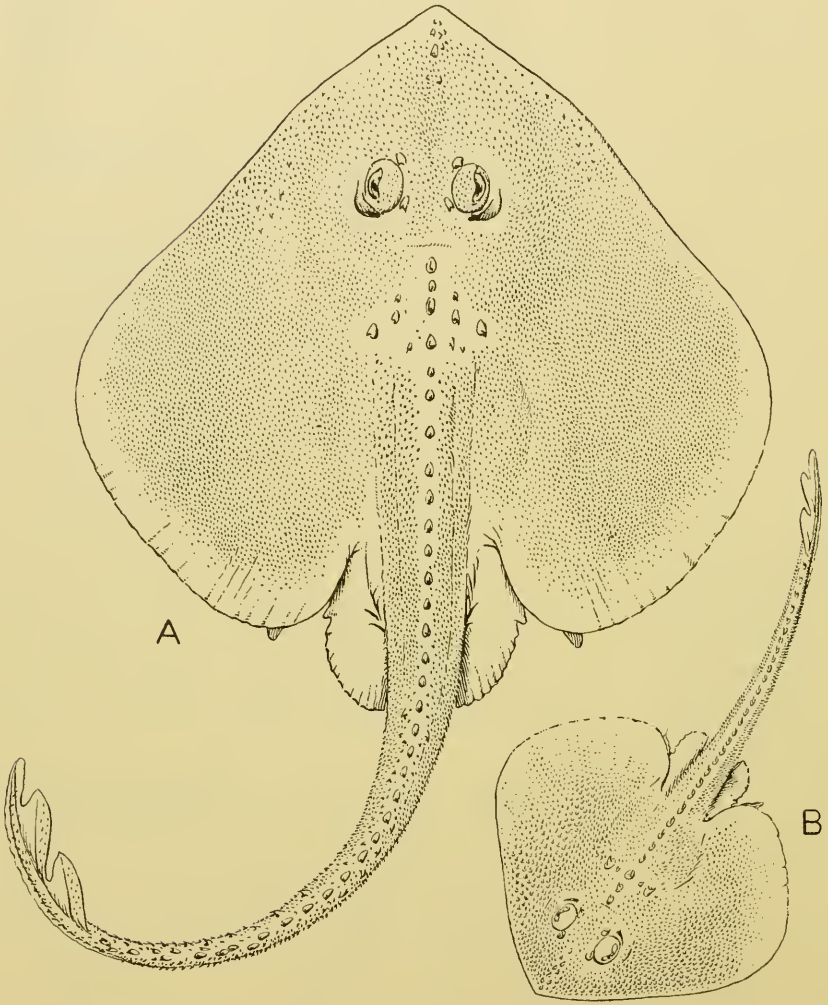

FIGURE 31. *Raja bathyphila*. *A* Immature male, about 328 mm long, from off southern Nova Scotia, Lat. 41°29′ N, Long. 65°36′ W, 1,188 fathoms (U. S. Nat. Mus., No. 148276). *B* Newly hatched male, about 117 mm long, from off New Jersey, Lat. 39°37′ N, Long. 71°08′ W, 835 fathoms (U. S. Nat. Mus., No. 148269).

Gill openings: lengths, 1st 1.1, 1.3; 3rd 1.2, 1.5; 5th 1.2, 1.3; distance between inner ends, 1st 12.8, 13.2; 5th 8.2, 8.4.

First dorsal fin: vertical height 2.3, 2.4; length of base 5.2, 4.9.
Second dorsal fin: vertical height 2.1, 2.1; length of base 5.8, 4.6.
Pelvics: anterior margin 11.0, 12.2.
Distance: from tip of snout to center of cloaca 41.5, 42.2; from center of cloaca to 1st dorsal 44.6, 45.0; to tip of tail 58.5, 57.8; from rear end of 2nd dorsal base to tip of caudal 3.3, 3.4.
Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc about 1.1 times as broad as long; maximum anterior angle in front of spiracles about 90° on smaller specimens but about 105° on larger; tip of snout rounded, not noticeably projecting; anterior margins nearly straight or slightly sinuous, the outer and posterior corners broadly rounded, the posterior margin weakly convex. Axis of greatest breadth about 77–78% of distance rearward from tip of snout toward axils of pectorals. Tail with narrow lateral folds along its posterior two-fifths, widest opposite pelvics; its length from center of cloaca about 1.1–1.2 times as great to first dorsal and 1.4–1.5 times as great to tip of tail as distance from center of cloaca to tip of snout.

Dorsal surface of disc on larger specimens with 3–6 medium to large thorns on radiate bases close behind tip of snout; several smaller ones along rostral cartilage; a row of 5–6 large thorns around inner margin of orbit, preceded by a few smaller ones close in front of eye; 1–2 larger thorns inward from inner end of spiracle; a group of up to 12–14 on nuchal region, small to large and irregularly distributed; three large thorns on each shoulder region, arranged like the mathematical symbol for the word therefore (∴), with a few smaller ones between these and the median line; also a median row of 30–35 from nuchal region to first dorsal (six from pectoral girdle to level of axils of pectorals), widely spaced anterior to level of axils of pectorals but closer together and decreasing a little in size toward first dorsal; tail with one to two irregular rows along either side in addition to the median row, the row lowest down on either side continuing about halfway along base of second dorsal. In addition to the larger thorns, the entire upper surface of the disc, including the skin above the eyes, is strewn with numerous smaller prickles on small specimens, except for naked areas along the posterior margins, and on the tip of the snout which continue so up to a length of 350 mm or more. With continued growth these marginal naked bands widen and additional naked areas develop on either side posterior to the scapular region as well as on either side of the rostral ridge, while the skin above the eyes loses most of its prickles; also, the prickles are relatively smaller and more closely spaced than on smaller specimens (illustrated by female 463 mm long, Fig. 30). Each side of the tail below the outermost row of thorns has a narrow band of close-set prickles along the anterior half, but thence rearward it is only sparsely prickly. And the prickles in this band are relatively larger and more thorn-like on younger Skates than on older ones. The dorsals of the smallest specimens are smooth, their upper parts are prickly on somewhat larger ones (316 and 350 mm); but on the largest ones seen there are only a few prickles. Caudal membrane smooth. The pelvics of some small specimens are prickly on the central part of the posterior lobe, but they are smooth on most, whether

larger or smaller.[81] Lower surface smooth, except along anterior part of tail where the lateral bands of prickles encroach somewhat on the lower surface.

A comparison of larger with smaller specimens shows that the total number of large thorns (28–35) in the median row is established early, there being six from the pectoral girdle to the level of the axils of the pectorals at the smallest size. There is only one row along the tail on the smallest seen, but the lateral rows develop along the posterior third when a length of about 300 mm is reached. These rows have extended forward to the level of the tips of the pelvics at a length of about 350 mm. The thorns on the snout (lacking on smallest seen) are present at a length of 316 mm; at first there are only two orbital thorns and one scapular on each side.[82]

Snout in front of orbits about 3.0–3.15 times as long as orbit, its length in front of mouth about twice as great as distance between exposed nostrils. Orbit about as long as distance between orbits and about 1.4 times as long as spiracle. First gill openings about 22–23 % as long as breadth of mouth; distance between inner ends of first gills about 2.0–2.2 times as long as distance between exposed nostrils, about 1.3–1.4 times between inner ends of fifth. Nasal curtain and expanded posterior (outer) margin of nostrils deeply fringed. Mouth, on females and immature males, a little arched forward centrally; its shape on mature males not known.

Teeth in 34–42 series in upper jaw, those of females close-set in quincunx, with moderately high conical cusp; those of mature males not seen.

Dorsals alike in shape and about equal in size, their bases confluent without intervening thorn. Caudal membrane, posterior to second dorsal, about 80 % as long as base of second dorsal. Pelvics deeply concave outwardly, their anterior margin about 63–70 % as long as distance from origin of pelvic to rear tip; anterior lobe slender, with three radials besides the first stout one and with rounded tip and deeply scalloped rear margin; posterior lobe strongly and evenly convex, scalloped anteriorly but only faintly wavy posteriorly; rear tip abrupt, extending about 1/4 of the distance from level of axils of pectorals toward first dorsal.

Anterior rays of pectorals extending forward about 2/3 of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface uniform grayish brown with greenish tinge (after many years in alcohol), without definite markings; outer edges of pectorals and pelvics shading to darker. Lower surface of disc and pelvics uniform chocolate brown, except for paleness on jaws; lower surface darker than upper. Smaller specimens similar except for paleness close over pectoral girdle; lower surface of tail paler chocolate brown.[83]

81. The pelvics on a female about 357 mm long are prickly as above but they are smooth on all the others we have seen.
82. There appears to be considerable variation, whether individual or geographic, in the stage at which the additional large orbital and scapular thorns first appear. A male of 117 mm has two oculars and one scapular on each side; an eastern Atlantic specimen of 184 mm (Holt and Byrne, Fish. Ireland Sci. Invest. [1906], 5, 1908: 57) had three oculars and two scapulars on each side; a male, 316 mm, two oculars and two scapulars, one smaller, on each side; a female about 350 mm (tip of tail damaged), three oculars on each side, two scapulars on one side and three on the other; a female 463 mm (largest seen), five and six oculars, and three scapulars on each side.
83. The lower surface of the type specimen from the Irish Atlantic slope is described as "brown, except the front of the snout, mouth parts and belly" (Holt and Byrne, Fish. Ireland Sci. Invest. [1906], 5, 1908: 53).

Remarks. The smaller specimens in our Study Material agree so closely (bodily proportions, dermal armature of disc and tail, and color) with the description[84] of the only specimen of *R. bathyphila* recorded previously that there seems to be no justification for separating them from that species unless future study should show that subsequent development follows a different course in the eastern Atlantic form from that illustrated by successive stages in the growth of the western Atlantic form. Thus we conclude that *R. bathyphila* is a well marked species rather than a young stage of *R. lintea* as has been suggested.[85]

Size. The young are hatched at a length less than 117 mm (our smallest specimen). The largest specimen seen (a female) is 463 mm long. But we have no clue as to the size to which this Skate may grow, for the claspers on the largest male (316 mm) still reach only about halfway rearward along the inner margins of the pelvics.

Developmental Stages. The egg cases have not been seen.

Habits. The great depths at which this Skate has been taken (835–1,188 fath. in the western side of the Atlantic and somewhere between 673 and 893 fath. in the eastern side) point to a strictly deep-sea habitat, as does the uniformly dark coloration. Nothing else is known of its habits.

Range. Both sides of the North Atlantic in deep water; Irish Atlantic Slope (type locality) in the east, a single young specimen; lower part of the continental slope in the west, from the offing of Chesapeake Bay to the offing of southern Nova Scotia. This is one of the few Skates that occur on both slopes of the North Atlantic basin.

Occurrence in the Western Atlantic. Five specimens have been taken so far in the western side of the Atlantic, all of them by the Albatross in the summers of 1884 and 1886 at the localities and depths given (p. 159, footnote 75).

Synonyms and References:

Raia bathyphila Holt and Byrne, Fish. Ireland Sci. Invest. (1906), 5, 1908: 51 (descr., meas., Irish Atlant. slope between 893 and 673 fath.); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 329 (descr., after Holt and Byrne, 1908).

Raia lintea (in part) Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 45 (considered synonym of *R. lintea* Fries 1838); Clark, Faune Ichthyol. Cons. int. Explor. Mer, 1930: pl. not numbered (considered synonym of *R. lintea* Fries 1838).

Raja lintea (in part) Jensen, Skr. zool. Mus. Kbh., *9*, 1938: 46 (considered synonym of *R. lintea* Fries 1838).

Raja eglanteria Bosc 1802

Brier Skate, Clear-nosed Skate, Summer Skate

Figures 32, 33, 34, 35

Study Material. Thirty-one specimens, male and female, 135–785 mm long, from: Woods Hole and 80–90 miles southward off Marthas Vineyard, Massachusetts; Middle Atlantic Coast; Chesapeake Bay; off Cape Hatteras (Lat. 35°26′ N, Long.

84. Holt and Byrne, Fish. Ireland Sci. Invest. (1906), 5, 1908: 51.
85. Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 45.

FIGURE 32. *Raja eglanteria*. *A* Female, 745 mm long, from Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36234). *B* Male, 704 mm long, from Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36233). *C* Posterior margin of nasal curtain of same, about 2.1×. *D* Margin of nostril of same, about 2.5×.

75°26′ W) and off Southport (Cape Fear), North Carolina; Charleston, South Carolina; Brunswick, Georgia; Pass-a-Grille and New Smyrna Beach, Florida; all in the Harvard Museum of Comparative Zoology, the Museum of Zoology, University of Michigan, and the U. S. National Museum; two egg cases, with young hatched from them, taken at Woods Hole, in Harvard Museum of Comparative Zoology; an embryo with large yolk sac and egg case fragments, from Florida, in the American Museum of Natural History.

Distinctive Characters. The presence of only a single row of thorns along the midridge of the back on the disc separates *R. eglanteria* from *R. erinacea*, *R. ocellata*, and *R. garmani;* the midrow of thorns extending forward to the region of the shoulders on *eglanteria* distinguishes it from *laevis* in which the midrow is confined to the tail; it is separated from *R. senta* in that the entire tail is thorny; the facts that the thorns of the midrow along the tail are not much larger than those of the lateral rows and that they number upwards of 18 separate it from *R. radiata*. The dark bars on the upper surface of its disc are also distinctive. Should its range prove to extend farther

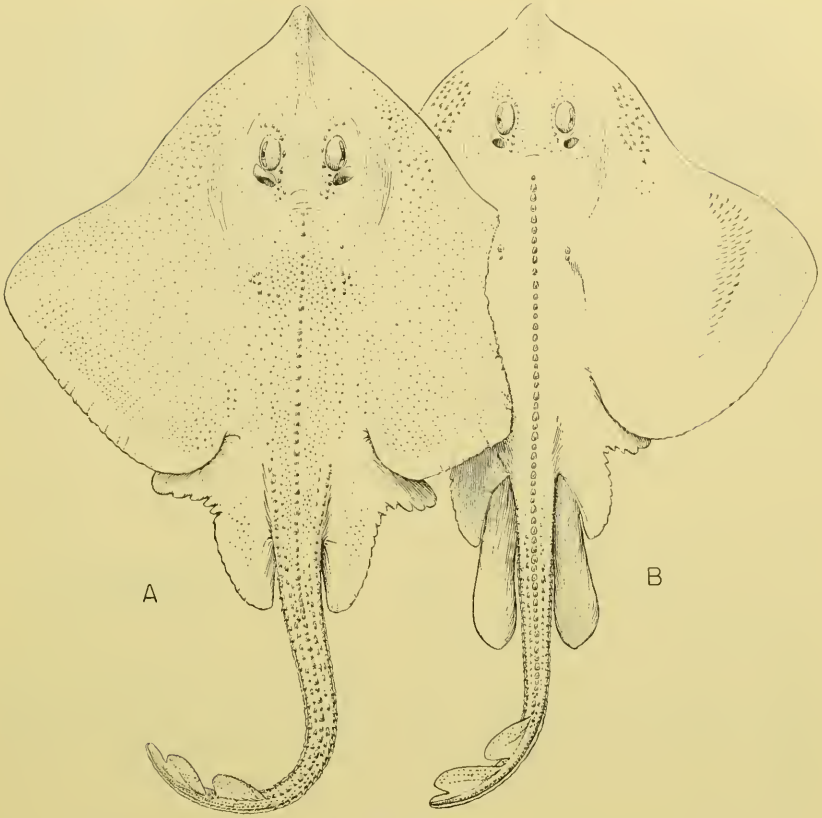

FIGURE 33. *Raja eglanteria*. *A* Female, 640 mm long, and *B* Male, 568 mm long, both from Charleston, South Carolina (Harv. Mus. Comp. Zool., Nos. 122 and 81).

southward than present records indicate, its color pattern of many small dark spots and bars without ocellar spots would serve to separate it from both *R. ackleyi* and *R. texana*.

R. eglanteria is not closely paralleled in shape of disc, distribution of thorns, and color pattern by any Skate so far known from the eastern North Atlantic, South Atlantic, or Pacific coasts of America.

Description. Proportional dimensions in per cent of total length. Male, 704 mm, and female, 745 mm, from Massachusetts (Harv. Mus. Comp. Zool., Nos. 36233 and 36234, respectively).

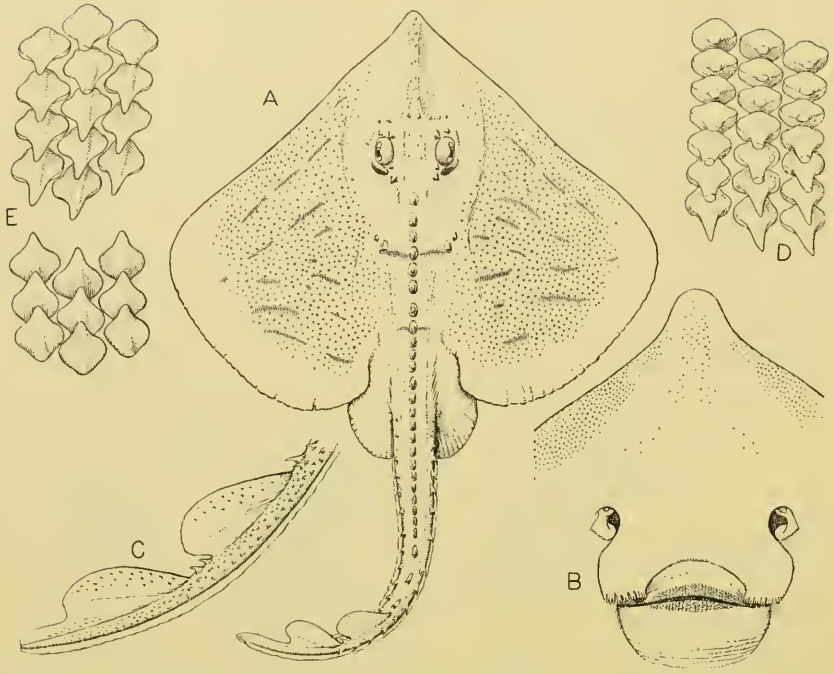

FIGURE 34. *Raja eglanteria*. *A* Female, 156 mm long, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36397), to illustrate juvenile color pattern and dermal armature. *B* Ventral view of anterior part of head of nearly mature male illustrated in Fig. 32, about 0.4×. *C* Lateral view of posterior part of tail of same, about 0.5×. *D* Upper teeth of same, about 5.5×. *E* Upper and lower teeth of female illustrated in Fig. 32, about 4×.

Disc: extreme breadth 66.8, 65.7; length 51.3, 53.7.
Snout length: in front of orbits 14.3, 15.3; in front of mouth 14.6, 16.8.
Orbits: horizontal diameter 3.8, 4.1; distance between 4.7, 5.0.
Spiracles: length 3.0, 3.0; distance between 6.5, 6.8.
Mouth: breadth 7.5, 8.7.
Nostrils: distance between inner ends 7.5, 8.0.
Gill openings: lengths, 1st 1.7, 1.9; 3rd 1.9, 2.1; 5th 1.3, 1.3; distance between inner ends, 1st 15.4, 16.0; 5th 8.8, 9.7.
First dorsal fin: vertical height 2.7, 2.7; length of base 6.1, 5.4.
Second dorsal fin: vertical height 2.2, 2.5; length of base 6.4, 6.4.
Pelvics: anterior margin 10.0, 12.2.
Distance: from tip of snout to center of cloaca 47.8, 51.5; from center of cloaca

to 1st dorsal 37.0, 32.3; to tip of tail 52.2, 48.5; from rear end of 2nd dorsal base to tip of caudal 2.0, 2.8.

Interspace between: 1st and 2nd dorsals 0.9, 1.6.

Disc about 1.2–1.3 times as broad as long; anterior contour about a right angle, a little more obtuse in southern specimens than in northern;[86] anterior margins weakly concave posterior to snout, weakly convex abreast of spiracles in females and only slightly more so in adult males; posterior corners broadly rounded, the outer corners more narrowly so. Axis of greatest breadth 73–76 % of distance back from tip of snout toward axils of pectorals. Tail with moderately wide lateral folds, its length from center of cloaca to origin of first dorsal about 0.7–0.8 as great, and from center of cloaca to origin of second dorsal about 0.8–0.9 as great, as distance from center of cloaca to tip of snout, on both large and small specimens.

Upper surface of disc with 1–5 thorns on each shoulder region;[87] 2–4 thorns at inner end of spiracle; 3–4 close behind orbit and as many close in front of it; also an irregular row around inner margin of orbit; a single continuous midrow, extending rearward along disc from nuchal region, the thorns varying in size from place to place (perhaps with age) and increasing in number with growth from 14–16 in small specimens (185–267 mm long) to 33–39 in those longer than 400 mm.

On southern specimens (Figs. 33, 34),[88] in addition to thorns, the upper surface of the disc, the base of the tail, and the central part of the pelvics is generally beset with small prickles from the time of hatching; females either continue so until maturity or may develop small naked areas outward and rearward from the shoulders. But mature males continue to be prickly only on the outer anterior parts of the pectorals, on the head outward from the eyes, in front of the eyes, and between the orbits. Northern examples[89] seem less rough; the upper surface of the disc and the pelvics is naked at hatching (Fig. 35) except for the characteristic thorns; later the females become prickly along the margins of the disc rearward from the level of the orbits (perhaps more generally so over pectorals in some cases), in a band along either side of the mid-dorsal ridge from the nuchal region rearward, over a patch in front of each orbit, along the edges of the rostral ridge, on the tip of the snout, and sometimes in the space between the orbits (Fig. 32). Mature northern males are prickly only along the anterior margins of the pectorals posterior to the level of the spiracles, over patches in front of the eyes, on the rostral ridge and tip of snout, and hence they are considerably smoother than adult females.

The tail, from the axils of the pectorals to the first dorsal, has a median row of about 16–19 moderately large thorns on newborn specimens which increase to 26–32

86. Maximum anterior angle in front of spiracles 90° in two specimens from Woods Hole; 100–105° in two from North Carolina and 92–105° in three from South Carolina.

87. One or two on large specimens of both sexes from Buzzards Bay, Massachusetts and on a female from Charleston, South Carolina; 3–5 on a smaller but sexually mature male from the latter locality. Sometimes these thorns are lacking.

88. Florida and South Carolina.

89. Woods Hole, Massachusetts.

on large; also, low down along either side of the tail of northern specimens there are 1–2 rows, 2–4 on southern. The dorsal fins are uniformly prickly at all sizes and in both sexes, the interspace between them having 1–3 thorns, larger or smaller. Sexually mature males have about 25–40 large thorns on the marginal region on each side about at the level of the eyes; the alar spines are arranged in 4–7 rows on the outer parts of the pectorals, there being about 28 spines in the innermost (longest) row. The lower surface on smaller specimens is smooth except for a prickly snout tip, but with growth the head becomes roughened with prickles rearward in a narrow band along the margins of the disc about to the level of the mouth on males, and a short distance farther on some females. Females also develop a prickly patch close in front of the axil of the pectoral. The lower surfaces of the pelvics are smooth on males but more or less prickly on large females.

Snout in front of orbits 2.7–3.1 times as long as distance between orbits; its length in front of mouth 1.7–2.2 times as great as distance between exposed nostrils. Orbit 1.2–1.4 times as long as spiracle; distance between orbits about 1.2 times as great as length of orbit.

Distance between first gill openings about 1.9–2.1 times as long as distance between exposed nostrils; fifth gill openings about 75 % as long as first; distance between fifth pair of gills 1.0–1.2 times as long as distance between exposed nostrils and about 0.9–1.2 times as long as breadth of mouth.

Nasal curtain fringed; expanded posterior (outer) margin of nostril also fringed. Mouth nearly straight in females, only a little more arched in adult males.

Teeth $\frac{46-54}{48-49}$ (four specimens) in transverse series, close-set, with low conical cusp, blunter on older rows and sharper on younger; sharper also on mature males than on females, especially along the younger (posterior) rows.

First and second dorsals similar in size and shape; interspace between them 14–30 % as long as base of first dorsal. Caudal membrane from rear end of base of second dorsal 32–53 % as long as base of first dorsal. Pelvics only moderately concave outwardly, more or less scalloped, most strongly so at base of marginal concavity; anterior margin about half as long as distance from origin of pelvic to rear tip; anterior lobe fleshy with rounded tip, including 4–5 slender radial cartilages as well as the first and stoutest; outer margin of posterior lobe nearly straight anteriorly, weakly convex toward narrowly rounded rear tip.

Anterior rays of pectorals extending about 55–65 % of distance from level of fronts of orbits toward tip of snout.

Color. A living specimen nearly three feet long, observed in an aquarium at Woods Hole, Massachusetts, was dark and light brown above, with many roundish spots as well as more elongate bars of the darker shade, and with irregular spots of the lighter shade about $\frac{3}{4}$–1 inch across; these markings appear on the tail as wide dark brown crossbars separated by light brown areas; the disc, pelvics, lateral edges of tail, and dorsal outlined with a narrow band of white. There is a translucent space on either side of the rostral ridge. The lower surface is white without dark markings. Other specimens

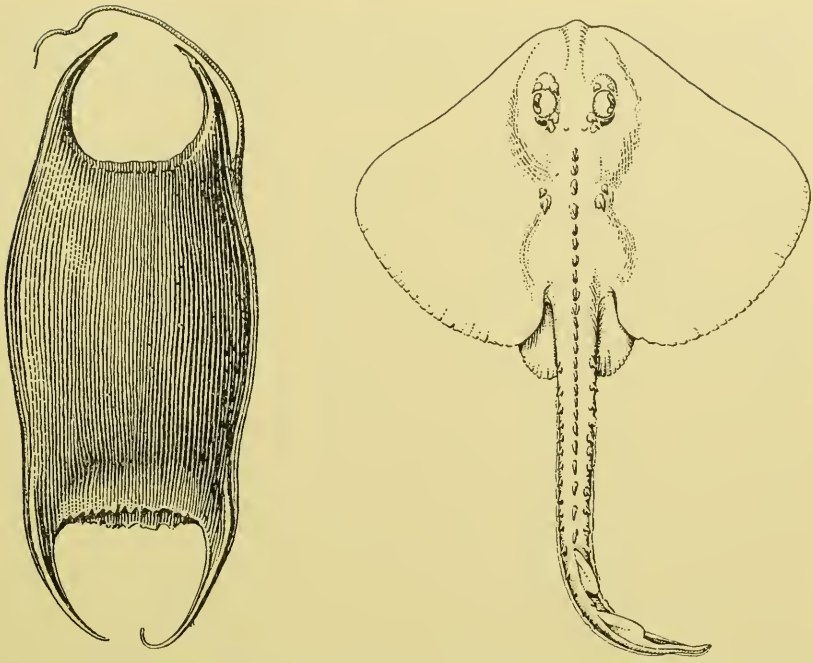

FIGURE 35. *Raja eglanteria*, from Woods Hole, Massachusetts. Egg case, and young skate hatched from it, about 0.9×.

have been described as brown or gray above, but all appear to have the characteristic dark spots and elongate bars.

Remarks. Attention has been called earlier to the greater prickliness of southern specimens (p. 169) and to the tendency for southern specimens to mature at a smaller size than the northern ones (p. 172). The series that we have studied is not sufficiently extensive or the geographic coverage sufficiently complete for us to judge whether or not these apparent differences indicate the existence of two separate races or subspecies of *eglanteria*—a southern (typical) form, and a northern form for which the name *americana* DeKay 1842 would appear to be available.

Size. At hatching, Woods Hole specimens are 135–144 mm long to the rear end of the second dorsal fin, our smallest Florida specimens 130 mm. In the northern part of its range some specimens of *R. eglanteria* may mature at a length of about 650 mm, but others probably not until 725 mm or longer.[90] Also, maturity may be

90. In the Block Island, Rhode Island, region males were found to mature at 750–770 mm (one at 620 mm) and females at 760–780 mm (from unpublished data at the Bingham Oceanographic Laboratory).

reached at a smaller size in the south, for the tips of the claspers of two males 568 mm long from Charleston, South Carolina, and 535 mm long from Pass-a-Grille (near Tampa), Florida, appear to have reached their full development. A specimen 30 inches long weighed 6 pounds and one of 31 inches $6^1/_2$ pounds.[91] A length of $37^1/_4$ inches is the greatest recorded.[92]

Developmental Stages. Eggs are probably laid in the spring, at least in the northern part of its range. A female 785 mm long, taken off southern Massachusetts[93] in January, had well developed ovaries with eggs 5–15 mm in diameter.

The egg cases range in size from about $2–3^1/_2$ inches long (without the horns) and $1^1/_2–2^1/_4$ inches wide,[94] those produced by Florida specimens being considerably smaller than those from New York[95] and Massachusetts specimens. The cases are of the usual Skate shape, the transverse margin being nearly straight and more or less ragged at the end with the longer pair of horns, but moderately concave at the end with the shorter pair. The horns are shorter than the egg case proper. At the end of the case with the longer horns, newly laid eggs in the aquarium had a thin, transparent, delicate area which subsequently sloughed away, thus forming a slit which probably serves the same respiratory function as do the slits on the horns in *Raja ocellata* (p. 246). But this was not visible in preserved specimens. Incubation occupies a period of at least three months[96] but it is not known how much longer. Newborn specimens already show dark markings somewhat similar to the adult pattern.

Habits. R. eglanteria breeds while inshore. A pair in coitus has been seen (and harpooned) off the coast of Virginia in the spring, "The male grasping the anterior part of the pectoral of the female from above with his teeth, and with claspers directed forward and well inserted."[97] A female brought in to the New York Aquarium from Sandy Hook in June laid two eggs the next day, and two more three days later. Egg cases, probably of this species, have also been found on beaches in August.

The stomachs of *R. eglanteria* that have been examined so far have contained fish, squid,[98] crabs and shrimps.[99]

R. eglanteria often comes so close to the land that it is taken regularly on hook and line from piers and jetties; however, it moves offshore for the cold months and has been taken in depths as great as 65 fathoms in January and February.

91. Average weights in the Block Island region were found to be: males 24.4 inches long, 2.61 pounds; 27.7 inches, 4.28 pounds; 29.25 inches, 4.64 pounds; females 24.5 inches, 3.18 pounds; 27.6 inches, 3.96 pounds; 32.7 inches, 7.65 pounds (from unpublished data at the Bingham Oceanographic Laboratory).
92. Schroeder, Bull. Boston Soc. nat. Hist., 66, 1933: 5.
93. Caught by the dragger EUGENE H., January 31, 1950 in 60 fathoms at about Long. 70° 30′ W.
94. Two egg cases from females taken off Marthas Vineyard, Massachusetts, were $3^1/_8$ by $2^1/_8$ and 3 by $2^1/_8$ inches.
95. For description and photographs of eggs laid in the New York Aquarium by a female taken near Rye, New York, see Breder and Nichols (Copeia, 1937: 181–183).
96. Eggs laid on June 15–18 in the New York Aquarium had died by September 13 (Breder and Nichols, Copeia, 1937: 182).
97. Fowler, Rep. N. J. Mus. (1905), 1906: 72.
98. In the Block Island, Rhode Island, region, the stomachs of *R. eglanteria* commonly contain squid throughout early summer. Butterfish (*Poronotus*) and scup (*Stenotomus*) are a dominant food during September and October (from unpublished data at the Bingham Oceanographic Laboratory).
99. For stomach contents of Chesapeake Bay specimens, see Hildebrand and Schroeder (Bull. U. S. Bur. Fish., *43*, 1928: 59).

In the northern part of its range, *R. eglanteria* is strictly a warm-season visitor in the shore waters. It appears in April in the sector between Chesapeake and Delaware bays and is present along New Jersey and near New York from mid-May (occasionally late April) through the summer into October (sometimes until November), but it is taken only from July until September off southern Massachusetts. It withdraws from the immediate vicinity of the coast during the hottest season in the more southern part of its range.[100] Thus, it has not been reported in July or August for Chesapeake Bay though common there in April, May, June, as well as September and October; and odd specimens only have been reported for July at Cape Lookout, North Carolina, where it is plentiful in April and May.[101]

The stock that summers to the northward appears to migrate southward and offshore in autumn, for specimens have been trawled in winter and early spring off southern Massachusetts,[102] New Jersey, Virginia and North Carolina.[103] However, it is doubtful whether the stock inhabiting the warmer waters from South Carolina south to Florida leave the coast at all during the winter.

The relationship of *R. eglanteria* to temperature is puzzling. Although its autumnal withdrawal from the immediate vicinity of the coast in the northern part of its range occurs when the upper few fathoms have chilled to about 13–16° C (about 55–61° F,)[104] all winter records for it have been from water as cold as 6.3–11° C (43.3–51.8° F);[105] also, it reappears along the shores of Virginia, New Jersey and New York when the water has warmed only a little from the winter minimum. The direction of temperature change may be the governing factor in its thermal migrations. It is possible also that this Skate is more sensitive to low temperatures in the southern than in the northern part of its range, for it is reported as appearing in abundance on the coast at Cape Lookout, North Carolina only after the water has warmed to about 12–17° C (54–63° F). In the northern part of its range[106] it has not been reported regularly anywhere in water warmer than perhaps about 21–22° C (70–72° F). Its presence along the New Jersey beaches throughout the summer might seem to contradict this statement, for the mean surface temperature there usually rises to at least about 23° C (73–74° F), and may reach 25° C (77° F). But those taken in pound nets at a depth of 20–30 feet

100. It is also said that it leaves New York Harbor during the hottest months, but reports conflict in this respect.
101. Unfortunately no information is available in this regard for any areas farther south.
102. We examined five specimens taken in 44 hauls while aboard the dragger EUGENE H., fishing 80–90 miles to the southward of Marthas Vineyard, Massachusetts, in 47–65 fathoms, January 27–February 3, 1950. These included females 297, 600, 640 and 785 mm long and a mature male with large claspers 760 mm long.
103. The U. S. Fish and Wildlife Service vessel ALBATROSS III trawled six specimens about 35 miles southeast of Cape Fear, January 31, 1950, in Lat. 33° 38′ N, Long. 77° 28′ W, in 13 fathoms; also two specimens, about a mile off Southport on February 7, 1950.
104. According to Breder (Copeia, 127, 1924: 27) it is not to be found in Sandy Hook Bay after the water cools to 14.4° C (58° F).
105. Specimens reported off northern New Jersey in 6–17 fathoms in January (Fowler, Copeia, 31, 1916: 41) may have been in water as cool as 5.5–6° C (42–43° F).
106. Taken only occasionally at Cape Lookout after the water has warmed to more than 21.1° C or 70° F (mid-May); absent from Chesapeake Bay during the period (July-August) when the bottom water is much warmer than that.

may actually be in water of considerably lower temperature due to inshore movements of cooler bottom water.[107]

In the southern part of its range (North Carolina to Florida)[108] *R. eglanteria* may inhabit somewhat higher temperatures than those in the north, but definite conclusions in this regard would be premature.

The highest salinity in which *R. eglanteria* has been taken is about 34 $^{0}/_{00}$, while those that enter Chesapeake Bay meet with salinities as low as 27–31 $^{0}/_{00}$ near the entrance and lower still if they venture up the Bay, as some do.[109] However, there is no evidence that *R. eglanteria* ever runs up into fresh water.

Numerical Abundance. R. eglanteria has been characterized repeatedly as "abundant" or as the "most numerous Skate" at various coastwise points between New Jersey and Virginia. There is an early report of not less than 10,000 pounds of them (weighing 1–5 pounds each) being discarded from one pound net on the New Jersey Coast on a single July day,[110] but this represented an exceptional concentration, even allowing for exaggeration. Ten specimens is the largest catch that has been reported from any one trawl haul on the wintering grounds offshore.

Relation to Man. Most of those caught by commercial fishermen and by anglers are discarded; however, a small percentage of the catch is utilized as food.

Range. Western North Atlantic from Massachusetts Bay to Florida, mostly in shoal water from close in to the coast out to about 65 fathoms.

Details of Occurrence. This Skate occurs regularly and plentifully at one season or another along the whole coastline of the United States from the northern part of Florida on both coasts to Long Island, New York.[111] To the northward and eastward, a few are taken yearly off southern New England and in the vicinity of Woods Hole; we caught two specimens in 10–15 fathoms on a hand line on Nantucket Shoals in July and September 1926.[112] Also, there are odd records for it from Provincetown at the tip of Cape Cod and from Gloucester at the northern boundary of Massachusetts Bay. To the southward, it has long been known on the South Carolina Coast —in fact, Charleston is the type locality; it has been taken off Brunswick, Georgia; many are caught off northern Florida;[113] and we have specimens from New Smyrna Beach farther to the southward. It has been recorded from the west coast of Florida but not from the northern shore of the Gulf of Mexico, but perhaps it is to be expected there. It is not known from any localities farther south than middle Florida.

107. Information is scant. On August 10, 1916 the surface close to Cape May was about 21.9 ° C (71° F), but the bottom at about 50 feet was only about 15.8° C (60° F).
108. Near Charleston, South Carolina the surface chills to about 10–11° C (50–52° F) in winter, warms to about 21.1° C (70° F) by mid-May, and is warmer than 24° C (75° F) from about mid-June to the end of September. Off the mouth of the St. Johns River, Florida the summer maximum is about the same and the winter minimum only a little higher; i. e., about 12.2–13.0° C (54–55° F) (Parr, Bull. Bingham oceanogr. Coll., *4* [3], 1933: 68, fig. 22).
109. Newcombe and Lang, Proc. Amer. phil. Soc., *81*, 1939: 399.
110. Smith, Bull. U. S. Fish Comm., *12*, 1894: 368.
111. Recorded repeatedly in scientific literature from many localities in New York, New Jersey, Delaware, Maryland, Virginia, lower Chesapeake Bay, and North Carolina.
112. Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 325.
113. Personal communication from Stewart Springer.

Synonyms and References:

Raja[114] *eglanteria* Bosc, in Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *2*, 1802: 104, 109, pl. 4, fig. 2 (descr., ill., Charleston, S. Carolina); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 462 (descr., New York); Garman, Proc. Boston Soc. nat. Hist., *17*, 1874: 179 (descr., Penikese I., Mass.); Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 188; 2nd ed., 1876: 159 (Chesapeake Bay); Yarrow, Proc. Acad. nat. Sci. Philad., [29], 1877: 217 (listed, near Beaufort, N. Carolina); Goode and Bean, Bull. Essex Inst., *11*, 1879: 28 (Essex County, Mass.); Bean, Proc. U. S. nat. Mus., *3*, 1880: 115 (Mass. and Conn.); Verrill, Amer. J. Sci., [3] *22*, 1881: 297 ("sparingly" in 130–160 f., at Gay Head); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 41 (descr., Atlant. Coast U. S.); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Bean, Rep. U. S. Comm. Fish. (1882), 1884: 343 (listed, Woods Hole); Jordan, Rep. U. S. 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Cod); Fowler, Rep. N. J. Mus. (1905), 1906: 72 (descr., nos., season, pair in coition; New Jersey, Delaware Bay, Virginia); Rep. N. J. Mus. (1906), 1907: 259 (New Jersey); Smith, N. Carolina geol. econ. Surv., *2*, 1907: 42 (descr., ill., C. Lookout, N. Carolina); Fowler, Rep. N. J. Mus. (1907), 1908: 131 (season, New Jersey); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 12 (New England locals.); Fowler, Proc. Acad. nat. Sci. Philad., *61*, 1909: 407 (Delaware Bay); Rep. N. J. Mus. (1908), 1909: 352 (New Jersey); Proc. Acad. nat. Sci. Philad., *62*, 1910: 470 (New Jersey); Gudger, Amer. Nat., *44*, 1910: 398 (near Beaufort, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *63*, 1911: 5 (egg cases, New Jersey); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Fowler, Proc. Acad. nat. Sci. Philad., *65*, 1913: 62 (nos., season, Maryland, Virginia); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 341, pl. 23 (descr., ill., Charleston, S. Carolina); Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 166 (season, nos., C. Lookout, Beaufort, N. Carolina); Nichols, Abstr. Linn. Soc. N. Y., 1913: 91 (season, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 738 (parasites, Woods Hole); Fowler, Copeia, 1914: 2 (listed, Maryland); Proc. Acad. nat. Sci. Philad., *65*, 1914: 62 (nos., season, Maryland); *66*, 1914: 353 (nos., season, Delaware); Coles, Proc. biol. Soc. Wash., *28*, 1915: 92 (nos., season, C. Lookout, N. Carolina); Fowler, Copeia, 27, 1916: 12 (New Jersey); Copeia, 31, 1916: 41 (winter, off New Jersey); Nichols, Copeia, 27, 1916: 9 (season, nos., near New York); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 272, pl. 45, fig. 1 (descr., ill., teeth, dermal armature, season, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *69*, 1917: 109 (New Jersey); Occ. Pap. Mus. Zool. Univ. Mich., No. 56, 1918: 2, 16 (New Jersey, Virginia); Copeia, 68, 1919: 13 (New Jersey); Latham, Copeia, 71, 1919: 54 (nos., weight, season, Long Island, New York); Fowler, Proc. Acad. nat. Sci. Philad., *71*, 1920: 293 (New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 145 (New Jersey); Latham, Copeia, 87, 1920: 91 (season, Long Island, New York); Copeia, 99, 1921: 72 (listed, Long Island, New York); Townsend, N. Y. zool. Soc., 25th Annu. Rep. (1920), 1921: 126 (listed, New York Bay); Townsend and Nichols, Copeia, 91, 1921: 10 (season, New York Harbor); Latham, Copeia, 112, 1922: 81 (season, Long Island, New York); Fowler, Proc. Acad. nat. Sci. Philad., *74*, 1923: 3, 6 (New Jersey); Breder, Copeia, 127, 1924: 27 (temp., New York); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 7, 9, 10, 29, 66 (cestode parasites, Woods Hole); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 64 (descr., ill., Gulf of Maine); Fowler, Copeia, 143, 1925: 41, 43 (Delaware and New Jersey); Copeia, 156, 1926: 146 (New Jersey); Breder, Zoologica N. Y., *4* (5), 1926: 243 (locomotion); Fowler, Copeia, 165, 1927: 89 (season, Delaware, Maryland); Nichols and Breder, Zoologica N. Y., *9*, 1927: 25 (ill., New York and south. New England); Fish Culturist, *7*, 1928: 225 (listed, New Jersey); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 58 (descr., ill., food, season, nos., Chesapeake Bay); Breder, Field Bk. Mar. Fish.

114. Also spelled *Raia*.

Atlant. Coast, 1929: 31 (genl.); Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1929: 608 (New Jersey); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 30 (descr., Maryland); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (listed, C. Cod to Florida); Breder, Copeia, 1932: 31 (season, Block Island); Wilson, Bull. U. S. nat. Mus., 158, 1932: 403 (copepod parasite, Woods Hole); Schroeder, Bull. Boston Soc. nat. Hist., 66, 1933: 5–6 (max. size, south. Mass.); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 32 (descr., ill., C. Ann to Florida); Bere, Amer. Midl. Nat., *17* (3), 1936: 583 (parasites, season, Englewood, Florida); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 325 (max. size, depth, south. Mass.); Breder and Nichols, Copeia, 1937: 181 (egg cases, New York, Florida; cf. other species); Fowler, Proc. Acad. nat. Sci. Philad., *89*, 1937: 304 (season, New Jersey); Breder, Bull. N. Y. zool. Soc., *41*, 1938: 28 (New York Harbor); Delsman, Mém. Mus. Hist. nat. Belg., (2) Fasc. 21, 1941: 65 (depth, off Jacksonville, Florida); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 160 (listed, S. Carolina).

Raja[115] *diaphanes* Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 478 (descr., shows it equal to *R. eglanteria* Bosc 1802, not *R. ocellata* Mitchill 1815, to which the majority of recent authors have referred it; New York); Ayers, Boston J. nat. Hist., *4*, 1843: 289, pl. 12, fig. 2 (ident. by ill., Long Island, New York); Linsley, Amer. J. Sci., *47*, 1844: 77 (ident. by ref. to Mitchill, 1815; Conn.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (ident. probable by name of "Summer Skate," Woods Hole).

Raia[116] *desmarestia* Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 100, pl. 4 (descr., ill., Florida); Müller and Henle, Plagiost., 1841: 154 (diagn. by ref. to Lesueur, 1824); DeKay, Zool. N. Y., 4, 1842: 372 (diagn. after Lesueur, 1824, Florida); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 511 (diagn., after Lesueur, 1824, Florida); Tuomey, Rep. Geol. S. C., 1848: app. XIII (listed, S. Carolina); Duméril, Hist. Nat. Poiss., *1*, 1865: 551 (descr., Charleston, S. Carolina); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 455, footnote a (ref. to Lesueur, 1824); Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (Florida, probably by ref. to Lesueur, 1824).

Raia eglanteria (in part) DeKay, Zool. N. Y., 4, 1842: 373 (but *R. eglantiera* Lesueur 1824, which equals *R. erinacea* Mitchill 1815, also included); Storer, Mem. Amer. Acad. Arts Sci., N. S., *2*, 1846: 512 (but *R. eglantiera* Lesueur 1824, which equals *R. erinacea* Mitchill 1815, also included); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (listed, Nova Scotia to Florida, but includes *R. eglantiera* Lesueur 1824, which equals *R. erinacea* Mitchill 1815).

Raia diaphanes (in part) Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 510 (descr. apparently also refers to *R. ocellata* Mitchill 1815); Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: 54, 57 (probably includes *R. ocellata* Mitchill 1815 because of descr. as abundant, south. Mass., April, May).

Probable References:

Raia americana DeKay, Zool. N. Y., 4, 1842: 368, pl. 66, fig. 215 (ident. probable from ill., New York); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed).

Raia ocellata DeKay, Zool. N. Y., 4, 1842: Fishes, pl. 65, fig. 212 (ill. apparently *R. eglanteria*, but perhaps not descr. on p. 369).

Raja eglantiera Tuomey, Rep. Geol. S. C., 1848: Append. XIII (listed, S. Carolina; probably *R. eglanteria* Bosc 1802, not *R. eglantiera* Lesueur 1824, which equals *R. erinacea* Mitchill 1815).

Not *Raia eglantiera* Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 103 (equals *R. erinacea* Mitchill 1815: see reference, p. 185).

Not *Raia eglanteria* Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (ref. to *R. eglantiera* Lesueur 1824, equals *R. erinacea* Mitchill 1815).

Raja erinacea Mitchill 1825

Little Skate, Hedgehog Skate

Figures 36, 37, 38

Study Material. Sixty-two specimens, from embryos to adults of both sexes, from many localities between St. Andrews, New Brunswick and the offing of Delaware

115. Also spelled *Raia*.

116. Also spelled *Raja*.

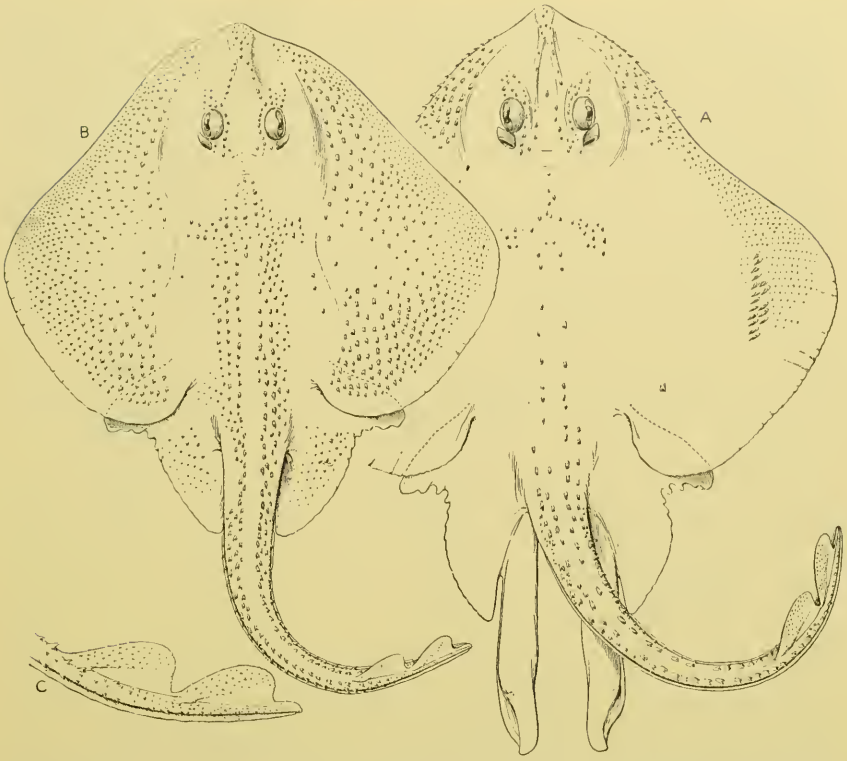

FIGURE 36. *Raja erinacea*. *A* Male, 507 mm long, from Boston Harbor, Massachusetts (Harv. Mus. Comp. Zool., No. 1021). *B* Female, 443 mm long, from Mystic, Connecticut (Harv. Mus. Comp. Zool., No. 1273). *C* Side view of posterior part of tail of same, about 0.7×.

(Lat. 38°32′ N), in the Harvard Museum of Comparative Zoology; three specimens from Kamouraska[117] (lower St. Lawrence River) and others in the U. S. National Museum; also a considerable number, identified by us but not preserved, trawled by the U. S. Bureau of Fisheries steamer ALBATROSS II and the U. S. Fish and Wildlife Service vessel ALBATROSS III at stations scattered along the continental shelf off southern New England and the mid-Atlantic United States.

Distinctive Characters. Females of *R. erinacea*, and males in which the claspers are still small, resemble specimens of *R. ocellata* so closely that the only sure means of identification is by counting the teeth; *R. erinacea* never has more than 66 series,

117. From V. D. Vladykov.

usually less than 54, in the upper jaw, while *R. ocellata* always has at least 72 series and usually more than 80.[118] In the case of sexually mature males, size is an equally dependable specific character, for *R. erinacea* grows only to a length of about 21 inches, whereas *R. ocellata* does not mature sexually until it has reached a length of at least 26–28 inches. Adults of *R. erinacea* resemble those of *R. fyllae* of West Greenland and the northeastern Atlantic in arrangement of thorns, in proportional dimensions, in the shape of snout, and in the fact that the two dorsals are confluent. But they are easily distinguishable from *R. fyllae* by their shorter tails and by the fact that the upper surface of *R. erinacea* between the thorns is smooth (partly spinulose in *R. fyllae*) and the margin of the disc less deeply concave opposite the spiracles. There is no dangre of confusing young specimens of the two; in *R. fyllae* the upper surface is uniformly prickly with the large thorns on the disc limited to the midline of the back, to the shoulders and to the head, whereas in the young of *R. erinacea* the disc as a whole is thorny with the skin smooth between the thorns. Neither *R. erinacea*, *R. ocellata*, nor *R. fyllae* is likely to be confused with any other Skate of the western North Atlantic, so characteristic are the thorn pattern, shape of disc, and proportionate dimensions of each.

R. erinacea falls closest to *R. naevus* Müller and Henle 1841 among European Skates in shape of disc, relative length of tail, distribution of thorns, and number of teeth; also, in the fact that the mid-dorsal row of thorns is lost with growth. However, the midbelt of the disc and the anterior part of the tail are thornier in *R. erinacea* than in *R. naevus*, whereas the upper surface of the disc is prickly generally between the thorns on *R. naevus* but naked between them on *R. erinacea*. The inner part of each pectoral, which is marked ordinarily with a conspicuous ocellar spot in *R. naevus*, is not so marked in *R. erinacea*. *R. erinacea* does not closely resemble any Skate known from the South Atlantic or from the Pacific Coast of America.

Description. Proportional dimensions in per cent of total length. Male, 441 mm, and female, 449 mm, from Massachusetts (Harv. Mus. Comp. Zool., Nos. 547 and 708 respectively).

Disc: extreme breadth 57.2, 57.7; length 46.5, 46.0.
Snout length: in front of orbits 9.9, 10.2; in front of mouth 9.5, 11.3.
Orbits: horizontal diameter 3.6, 3.8; distance between 4.8, 4.9.
Spiracles: length 2.9, 2.9; distance between 6.8, 6.9.
Mouth: breadth 8.0, 8.2.
Nostrils: distance between inner ends 6.8, 6.2.
Gill openings: lengths, 1st 1.7, 1.8; 3rd 2.0, 1.9; 5th 1.6, 1.6; distance between inner ends, 1st 14.1, 15.1; 5th 7.3, 8.9.
First dorsal fin: vertical height 2.8, 3.1; length of base 6.6, 6.7.
Second dorsal fin: vertical height 2.5, 2.9; length of base 5.9, 6.2.
Pelvics: anterior margin 13.6, 11.6.
Distance: from tip of snout to center of cloaca 44.3, 45.4; from center of cloaca

118. See p. 242, footnote 74.

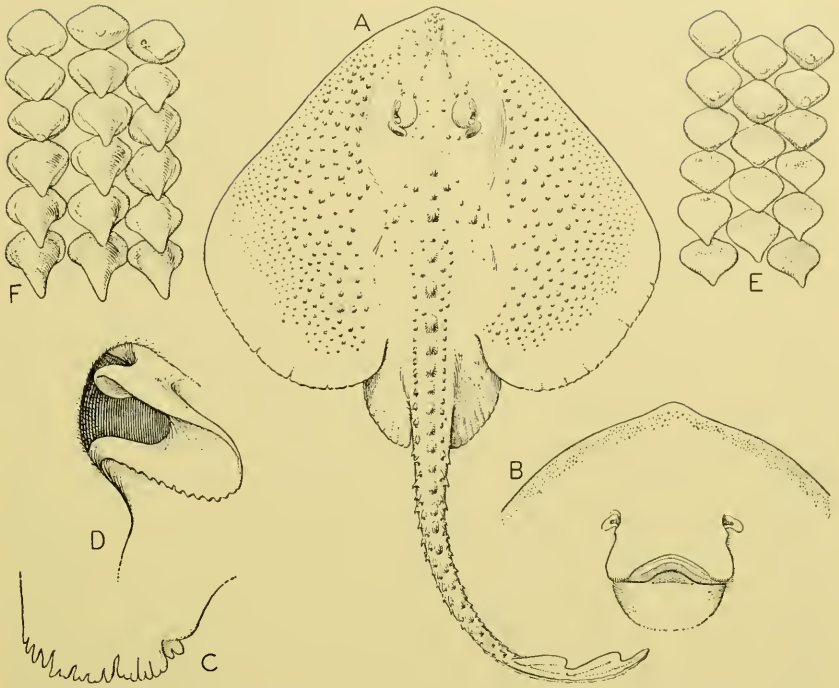

FIGURE 37. *Raja erinacea*. *A* Juvenile male, 180 mm long, from off New Jersey, Lat. 39°11′ N, Long. 73°40′ W, 23 fathoms (Harv. Mus. Comp. Zool., No. 34399), showing dermal armature. *B* Lower surface of anterior part of head of female, 460 mm long, from Mystic, Connecticut (Harv. Mus. Comp. Zool., No. 1270). *C* Posterior margin of nasal curtain of same, about 4.1×. *D* Outer posterior margin of nostril of same, about 4.1×. *E* Upper teeth near middle of jaw of female, 445 mm long, from off Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36228), about 10×. *F* Upper teeth near middle of jaw of mature male, 440 mm long, from off Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36230), about 10×.

to 1st dorsal 41.5, 39.5; to tip of tail 55.7, 54.6; from rear end of 2nd dorsal base to tip of caudal 1.8, 2.2.

Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc about 1.2 times as broad as long, extremely obtuse in front, the maximum anterior angle in front of spiracles about 110–130°; anterior margins weakly concave for a short distance behind tip of snout, thence evenly and weakly convex rearward to outer corners of disc in newly hatched specimen; weakly concave opposite spiracles in medium-sized specimen and adult females, but much more deeply so in adult males; outer and posterior corners broadly rounded, posterior margins evenly and moderately

convex; inner margins convex to axils. Axis of greatest breadth about 70–72 % of distance back from tip of snout toward axils of pectorals. Tail with narrow lateral folds low down along posterior two-thirds, its length from center of cloaca to origin of first dorsal about 1.1 times as great as distance from center of cloaca to tip of snout in newly hatched specimen, decreasing relatively to about 0.85–0.95 that great in adults; distance from center of cloaca to tip of tail 1.2–1.35 times as great as distance from cloaca to snout after embryonic prolongation is lost (4 specimens, 441–452 mm long).[119]

On newly hatched specimens, upper surface conspicuously rough; inner and anterior parts of pectorals closely set with thorns, the largest posteriorly; 6–10 thorns on each shoulder region; 2–3 behind each eye, with two or more in front of it; 2–3 along inner margin of orbits, and a few in space between orbits; a row along either edge of rostral cartilage, with a group of thorns of various sizes on tip of snout; also a regular mid-dorsal row of about 5 or 6 thorns on disc rearward from pectoral girdle and 15–17 on tail, flanked by a lateral row on either side extending equally far rearward; another less regular row lower down along anterior half of tail. With growth the thorns increase in number to: 2–4 irregular rows along either side of midline of disc and of anterior part of tail; 1–2 rows near tip of tail; an irregular triangular group of about 30–60 covering nuchal and shoulder region; 3–8 behind eye and 8–15 in front of it; 9–12 along inner margin of orbit and several between orbits; and an irregular double row along each edge of rostral cartilage, with a cluster at tip of snout. On the other hand, some of the large thorns are lost progressively from the inner parts of the pectorals, their anterior margins continuing rough with large thorns. Specimens from the Gulf of Maine and southward also lose the median row of thorns posterior to the nuchal region by the time a length of 300–350 mm is reached, but mature individuals (to at least 469 mm) that we have seen from the lower St. Lawrence River still bear this median row of thorns. Skin of disc and tail smooth between thorns in all specimens examined. Both dorsals prickly posteriorly in small specimens and prickly toward margins on larger. Pelvics prickly on small specimens; naked or with only a few small thorns on larger males and on partly grown females, but with a thorny area developing on mature females.

At sexual maturity the outer posterior parts of the pectorals become increasingly thorny in females, but maturing males lose most of the thorns from the inner parts of their pectorals and some from the mid-dorsal ridge, so that they are noticeably smoother than mature females, but there is wide variation from specimen to specimen. Alar spines of mature males in 2–3 rows on outer two-thirds of pectoral; 13–14 spines in each of inner two rows, 5–7 in third row.

Lower surface wholly naked in newly hatched specimens, but snout soon becoming prickly, the rough area expanding as a narrow band along margin of disc about to level of nostrils in half-grown specimens, about to level of mouth in adults.

119. In three specimens, 346–469 mm long, from the St. Lawrence River, the distance from cloaca to tip of tail was only 0.93–1.18 as great as the distance from snout to cloaca.

Snout in front of orbits 1.9–2.4 times as long as distance between orbits, its length in front of mouth 1.5–2.0 times as great as distance between exposed nostrils. Orbit about 1.0–1.4 times as long as spiracle; distance between orbits 1.1–1.7 times as long as length of orbit.

Distance between first gill openings 2.0–2.4 times as long as distance between exposed nostrils, between fifth gill openings 1.1–1.4 times; first gill openings 1.0–1.6 times as long as fifth and about 18–26 % as long as breadth of mouth.

Nasal curtain fringed; expanded posterior (outer) margin of nostril fringed finely or coarsely. Mouth broadly bowed, the lower jaw much more narrowly arched in adult males than in females, the upper jaw somewhat more so to accomodate it.

Teeth $\frac{38-64}{38-64}$; low in young of both sexes and of females to maturity, rounded with faintly marked transverse cutting edges, in quincunx arrangement; those of mature males about as high as broad, with sharp or only slightly blunt points, more widely spaced in transverse series.

First and second dorsals similar in size and shape, confluent at base. Caudal membrane from rear end of base of second dorsal about 27–35 % as long as base of first dorsal.[120] Pelvics moderately concave outwardly, scalloped around indentation; anterior margin about 51–64 % as long as distance from origin of pelvic to rear tip; anterior lobe broad with well rounded tip, including about five slender radial cartilages besides first stout one; posterior lobe with weakly and evenly convex outer margin and rather narrowly rounded tip.

Claspers of mature males reaching about midway from axils of pelvics toward tip of tail. One of the terminal cartilages[121] is a broad scimitar-shaped blade with a sharp cutting edge, covered with thin skin, its recurved point directed forward along the outer ventral side of the clasper channel. This blade, which is entirely enclosed within the leaf-like walls of the clasper, is exposed after the latter has been inserted in the female.

Anterior rays of pectorals reaching about 68–76 % of distance from level of fronts of orbits to tip of snout.

Color. Upper surface grayish to dark brown or clouded with light and dark brown, usually with small round to oval darker spots varying in size and arrangement on different parts of disc and on different specimens. Lower surface usually white or pale gray without markings; disc and tail occasionally with irregular dusky blotches, or entire lower surface of tail dark gray.[122]

Size. Length at hatching is about 75–85 mm, the usual length at maturity about 450–500 mm (18–20 in.) in both sexes; the largest specimen recorded was about 530 mm long (21 in.).[123] One 18 inches long weighs about 1.3 pounds.

Developmental Stages. The eggs are often taken in considerable numbers in nets

120. 8–20 % as long in three specimens examined from the St. Lawrence River.
121. Cartilage T^3, according to the terminology adopted by Jungersen (Danish 'Ingolf' Exped., *2* [2], 1898: 10); often termed the thorn or spine.
122. All these variations are illustrated on specimens in our Study Material.
123. A specimen in the Harvard Museum of Comparative Zoology.

or dredges in a few fathoms of water, and the empty cases cast up on the beach are familiar objects. They are amber or golden yellow when first laid but are almost black when found empty. The average dimensions are 55–63 mm long (exclusive of the horns) by 34–45 mm broad.[124] The transverse margin at the end bearing the longer pair of horns[125] is straight or somewhat ragged, the margin at the end with the shorter horns either weakly convex, straight, or more or less concave; the two lateral faces are convex so long as the case contains its embryo. The horns taper to slender tips, and they are so fragile that ordinarily only the basal parts are intact on empty cases. The longer horns are nearly straight, the shorter pair more or less curved, one toward the

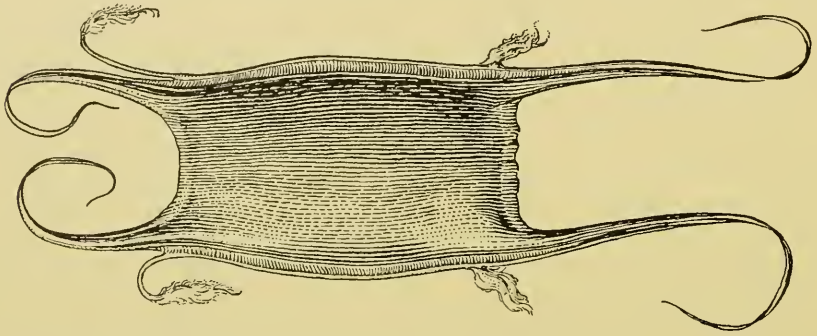

FIGURE 38. *Raja erinacea*, egg case, from Buzzards Bay, Massachusetts, about 1.1 ×.

other.[126] The lateral margins are fringed with thin hair-like elastic and adhesive fibers so tangled together as to form a sort of false membrane that accumulates sand or broken shells and serves to anchor the case. Respiratory slits do not exist at the time the egg is laid but are present before hatching (p. 142).

In embryos nearly ready for release, the tail posterior to the second dorsal fin may be as long as the disc from snout to axil of pectoral; and in some young specimens the terminal prolongation may still be as long as the distance from the origin of the first dorsal to the rear end of the base of the second dorsal. But in others more recently hatched, as indicated by their smaller size, the tail may have shrunk nearly to its adult proportions.[127] Newly hatched specimens differ noticeably from adults in their dermal armature (see p. 180).

Habits. This Skate, like most others, is usually found on sandy or gravelly bottom, less often on mud and rarely on submarine rocks or ledges. Also, it is more plentiful in

124. Daniel Merriman and Yngve H. Olsen advise us that in Long Island Sound the median length is as small as 46 mm and the median width as small as 27 mm.
125. It is from this end that the young Skate is released.
126. For photographs of egg cases, see Vladykov (Nat. canad., [3] 7, 1936: 213, 216) and Breder and Nichols (Copeia, 1937: 182).
127. For an account of the cleavage of the egg, see Ryder (Bull. U. S. Fish Comm. [1886], 6, 1887: 8).

water shoaler than 15–18 fathoms than in deeper water, while many come so close in shoreward that they are often found stranded on the beach, especially after rough weather. The greatest depths from which positively identified specimens have been recorded are 31–44 fathoms off the coasts of Virginia, Delaware, New Jersey, and Long Island, New York;[128] 71–80 fathoms off southern Massachusetts;[129] 30 fathoms on the southwestern part of Georges Bank;[130] 25 fathoms near Seguin Island, Maine; and 50 fathoms off the Bay of Fundy.[131] It tolerates a wide range of temperature, from about 20–21° C (68–70° F)[132] in summer to as cold as about 3–4° C (37–39° F) in winter.[133] Specimens have survived until heated to 29.1–30.2° C (84.4–86.4° F), even though taken from the cool water of Passamaquoddy Bay.[134]

The maximum salinity recorded on bottom within the zone regularly inhabited by *R. erinacea* is 33.8 ‰, the usual upper limit a little less than 33 ‰. The great majority of the population lives in salinities lower than 32.5 ‰ the year round, but 29–30 ‰ is about the lower limit of its optimum range, except in Long Island Sound, where it is found in water with salinity of only about 27 ‰. It has never been reported from fresh water, and specimens placed in the latter showed signs of great physiological disturbance.[135]

Stomach contents listed for *R. erinacea* include hermit and other crabs (*Cancer*, *Ovalipes*, *Panopaeus*, *Pagurus*), shrimps, amphipods, copepods, annelid worms (chiefly *Nereis*), ascidians, bivalves including razor shells (*Ensella*), and fragments of squids. Crabs are an important item, for 29 % of the Skates opened in one series of examinations at Woods Hole contained them, 15 % contained bottom-living shrimps of one kind or another, and 6 % had eaten squid. In Long Island Sound, amphipods were found to be the chief food, followed by crabs and shrimp (see above). It also preys on small fish, including the sand launce (*Ammodytes*), alewives (*Pomolobus*), herring (*Clupea*), cunners (*Tautogolabrus*), silversides (*Menidia*), tomcod (*Microgadus*), flounders (*Paralichthys*), and silver hake (*Merluccius*).

It appears that *R. erinacea* produces eggs throughout its latitudinal range, except perhaps toward its southern limits, for egg cases have been found as far north as Halifax Harbor, Nova Scotia.[136] For an account of fertilization and egg laying, see p. 188.

R. erinacea probably does not carry out any extensive migrations along the coast with the change of seasons. It has been described repeatedly as coming up into shallower water for the summer and moving out into deeper water in autumn or early winter.

128. Specimens collected by the U. S. Bureau of Fisheries steamer ALBATROSS II and examined by us.
129. Specimens trawled on the ALBATROSS III.
130. Ten specimens trawled on September 5, 1926, during one of the cod tagging cruises of the U. S. Bureau of Fisheries. It was not represented among the Skates taken in 37 trawl hauls at 40 fathoms or deeper on the northern part of the Bank in September 1929. For details of these catches, see Bigelow and Schroeder (Bull. U. S. Bur. Fish., *48*, 1936: 324).
131. Huntsman, Contr. Canad. Biol. (1921), 3, 1922: 57. 132. Off New Jersey and southern New England.
133. Shoal water off the eastern end of Long Island, New York, and off Connecticut; also southern side of Gulf of St. Lawrence.
134. Huntsman and Sparks, Contr. Canad. Biol., N. S. *2*, 1924: 102.
135. Chaisson (Contr. Canad. Biol., Fisher., N. S. *5*, 1930: 479).
136. Vladykov, Nat. canad., *63* [(3)*1*], 1936: 213, 215.

But this seasonal shift in depth appears to be less than has sometimes been stated, for Little Skates are taken in winter in fish traps near New York in depths not greater than 20–30 feet, are trawled regularly throughout the winter off the Connecticut shore and off southern Massachusetts in 15–20 fathoms, and specimens tagged in June near Block Island, Rhode Island, were recaught nearby the following winter and spring.[137] But it is also present in winter and spring in depths as great as 70–80 fathoms off southern New England and on southern Georges Bank where it probably is a year-round resident.[138] It has also been reported off North Carolina in winter in depths greater than 30 fathoms.[139]

Numerical Abundance. This is not only the commonest Skate along the coasts of New England but the most familiar because of its habit of coming into shoal water. More exact information as to its abundance is found in the report that during one series of observations a trawler took an average of 98.8 pounds of them per hour in Long Island Sound, August 1943 to January 1944;[140] during a second series, 1944–1946, 36 hauls yielded an average of around 200 specimens per haul;[141] and several hundred a day are sometimes landed at Woods Hole by draggers during the winter for preservation as teaching material for students of zoology.

Relation to Man. This Skate is seldom used as food, but small numbers are utilized for baiting eel and lobster traps and some are used as zoological specimens.

Range. Western North Atlantic, North Carolina to Nova Scotia and southern side of Gulf of St. Lawrence; from near shore out to about 80 fathoms.

Details of Occurrence. The lower St. Lawrence River and southern shore of the Gulf of St. Lawrence,[142] including the Bay of Chaleur, appear to be its most northerly outposts, for it has not been reported anywhere else within the Gulf, from Newfoundland (coastwise or offshore) or from Labrador. But it is described as "very common"[143] all along the Atlantic Coast of Nova Scotia. It is plentiful along both shores of the Bay of Fundy and is generally distributed in suitable situations all around the northern and western coastline of the Gulf of Maine, including its larger bays (e. g., Massachusetts Bay) and interinsular passages. It is plentiful also along Cape Cod, on southwestern Georges Bank, off the southern coast of Massachusetts, around the islands of Nantucket and Marthas Vineyard, in Rhode Island waters, along the coast of Connecticut, on both shores of Long Island, near New York Harbor, and along New Jersey. It

137. Reported by Daniel Merriman as a result of tagging experiments conducted in June 1946 by the Bingham Oceanographic Laboratory.

138. We trawled one January 27, 1950 in 55 fathoms south of Block Island on the dragger EUGENE H. On a cruise of the ALBATROSS III, May 11–17, 1950, we took the following specimens in trawl hauls between Hudson Canyon and 69° 10′ W: 47 in 6 hauls, 20–30 fath.; 77 in 8 hauls, 31–40 fath.; 55 in 15 hauls, 41–50 fath.; 7 in 11 hauls, 51–60 fath.; 8 in 6 hauls, 61–70 fath.; 18 in 9 hauls, 71–80 fath.; 0 in 8 hauls, 101–250 fath.

139. Specimens reported by the ALBATROSS III as taken in January 1950 in the vicinity of Cape Lookout, North Carolina.

140. Merriman and Warfel, Trans. 9th N. Amer. Wildl. Conf. (1944): 234.

141. Merriman and Warfel, Bull. Bingham oceanogr. Coll., *11* (4), 1948: 148, 157.

142. Halkett, Check List Fish. Canada, 1913: 42, "Gaspe Bay"; Cox, Bull. nat. Hist. Soc. New Brunsw. 13, 1895: 63. There is also a specimen from Prince Edward Island in the American Museum of Natural History.

143. Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51.

is known from Delaware Bay, the coast of Maryland and northern Virginia, and it has been reported from deep water off Cape Lookout, North Carolina.[144] We have examined specimens[145] that were trawled at stations scattered along the continental shelf southward to the offing of Chesapeake Bay in depths of 14–44 fathoms. In Chesapeake Bay it has been reported from Tangier Sound in the lower third of the Bay and at Hampton and Cape Charles, Virginia, near the mouth.

Owing to its preference for shallow water (p. 183), the majority of the population of *R. erinacea* is confined to a narrow coastline belt perhaps not more than 20–25 miles wide between the offings of Delaware Bay and New York, 10–12 miles wide along the southern Long Island shore, 40–60 miles wide off southern Massachusetts (including Nantucket Shoals) and widening to 60–80 miles or more to include the shoaler parts of Georges Bank (p. 184), and about 15–30 miles wide (measured from the nearest land) around the shores of the Gulf of Maine in general.[146]

No information is available as to its presence or absence on the offshore Nova Scotian Banks. However, there are considerable areas shoaler than 20–30 fathoms on Sable Island Bank, and similar smaller areas exist on Browns and Banquereau Banks which may offer a suitable habitat for it unless the temperature there falls too low for its welfare during part of the year (see discussion, p. 183).

Synonyms and References:

Raia eglantiera[147] Lesueur, J. Acad. nat. Sci. Philad., 4 (1), 1824: 103 (descr. of Philad. specimen ident. as *R. erinacea* by dermal armature and small size of male with large claspers).

Raja erinaceus[148] Mitchill, Amer. J. Sci., *9*, 1825: 290 (descr., ill., New Jersey; type specimen sent to Paris); DeKay, Zool. N. Y., 4, 1842: 372, pl. 78, fig. 246 (ill., New Jersey); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 512; Synopsis Fish. N. Amer., 1846: 259, 260 (diagn., size, New Jersey); Perley, Cat. Fish. New Brunsw. and Nova Scotia, 1st ed., 1851: 39 (Grand Manan I.); Rep. Fish. Bay of Fundy, 1851: 155 (Grand Manan I.); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed, Atlant. Coast N. Amer.); Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: 54, 57 (south. Mass., Conn.); Baird, Rep. U. S. Comm. Fish. (1871–1872), *1*, 1873: 826 (listed, Woods Hole); Gill, Rep. U. S. Comm. Fish. (1871–1872), *1*, 1873: 812 (listed, C. Cod to Florida); Garman, Proc. Boston Soc. nat. Hist., *17*, 1874: 176 (descr., Mass. Bay and mouth of Connecticut R.); Goode and Bean, Bull. Essex Inst., *11*, 1879: 28 (Mass., but *R. ocellata* also included); Bean, Proc. U. S. nat. Mus., *3*, 1880: 115 (Mass. and Conn.); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 40 (descr., size, nos., range); Bean, Rep. U. S. Comm. Fish. (1882), 10, 1884: 343 (listed, Woods Hole); Rathbun, Proc. U. S. nat. Mus., *7*, 1885: 485 (parasites, Woods Hole); Jordan, Rep. U. S. Comm. Fish. (1885), 13, Append. E, 1887: 799 (listed, N. Atlant. states); Ryder, Bull. U. S. Comm. Fish. (1886), *6*, 1887: 8 (early embryol.); Linton, Rep. U. S. Comm. Fish. (1886), 1889: 460, 462 (parasites); Rep. U. S. Comm. Fish. (1887), 1891: 766, 840 (parasites); Goode and Bean, Smithson. Contr. Knowl., *30* (Publ. 981), 1895: 28;

144. It was credited to South Carolina by True (List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261), but seemingly this harks back to the fact that it was confused with *R. eglanteria* by Lesueur (J. Acad. nat. Sci. Philad., *4*, 1824: 103, 105). Nor do we find any factual basis for Gill's (Rep. U. S. Comm. Fish. [1871–1872], *1*, 1873: 812) report of it as occurring "to Florida."

145. Some in the U. S. National Museum, others collected during the cruises of the U. S. Bureau of Fisheries steamer Albatross II.

146. Twenty-two trawl hauls, made by the Atlantis in August 1936 in the deeper troughs farther out in the Gulf of Maine, did not yield a single *R. erinacea*, though three other species (*R. senta*, *R. radiata*, and *R. laevis*) were taken.

147. Obvious misspelling for *eglanteria*.

148. The spelling was corrected to "*erinacea*" by Storer (1846) who, with some authors, has preferred the spelling *Raia* to *Raja*.

Spec. Bull. U. S. nat. Mus., No. 2, 1895: 28; Mem. Harv. Mus. comp. Zool., *22*, 1896: 28 (New England); Cox, Bull. nat. Hist. Soc. New Brunsw., *13*, 1895: 63 (Grand Manan I., and S. Gulf St. Lawrence); Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, Virginia to Maine); Bull. U. S. nat. Mus., 47 (1), 1896: 68 (descr., Virginia to Maine); Bean, Bull. Amer. Mus. nat. Hist., *9*, 1897: 331 (egg cases, New York); Linton, Proc. U. S. nat. Mus., *20*, 1898: 423, 440, 450 (parasites, Woods Hole); Bumpus, Science, N. S. *8*, 1898: 851 (season with eggs, Woods Hole); Smith, Bull. U. S. Fish Comm. (1897), *17*, 1898: 89 (nos., Woods Hole); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (4), 1900: pl. 9, fig. 29 (ill.); Bean, 6th Rep. For. Comm. N. Y., 1901: 382 (season, range); Gorham, Bull. U. S. Fish Comm., *19*, 1901: 34 (physiol., Woods Hole); Linton, Bull. U. S. Fish Comm. (1899), *19*, 1901: 274 (stom. contents); Bull. U. S. Fish Comm. (1899), *19*, 1901: 430 (food, parasites); Bean, Bull. N. Y. St. Mus., 60, Zool. *9*, 1903: 47 (descr., habits, egg cases, New York); Sharp and Fowler, Proc. Acad. nat. Sci. Philad., *56* (2), 1904: 506 (Nantucket); Parker, Bull. U. S. Bur. Fish. (1904), *24*, 1905: 190, 196, 197, 202 (physiol. lateral line syst.); Wilson, Proc. U. S. nat. Mus., *28*, 1905: 571, 573, 575, 631 (parasites); Bull. U. S. Bur. Fish. (1904), *24*, 1905: 131 (parasites); Fowler, Rep. N. J. Mus. (1905), Pt. II, 1906: 70 (descr., New Jersey); Tracy, 36th Rep. R. I. Comm. inl. Fish., 1906: 47 (descr., food, breeding season, Rhode Island); Field, Rep. U. S. Comm. Fish. (1906), Spec. Pap. [6], Doc. 622, 1907: 23 (descr., food, Woods Hole); Fowler, Rep. N. J. Mus. (1906), Pt. III, 1907: 257 (descr., New Jersey); Rand, Amer. Nat., *41*, 1907: 287 (spiracular breathing); Sullivan, Bull. U. S. Bur. Fish. (1907), *27*, 1908: 13 (physiol. digestive syst.); Fowler, Rep. N. J. Mus. (1907), Pt. III, 1908: 128 (color, size, Delaware Bay); Gill, Smithson. misc. Coll., *52*, 1910: 159, fig. 46 (ill.); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 10 (New England locals.); Smallwood, Science, N. S. *28*, 1908: 930 (abnormality); Sumner, Bull. U. S. Bur. Fish. (1908), *28* (2), 1910: 1246 (distrib. off Marthas Vineyard); Fowler, Proc. Acad. nat. Sci. Philad. (1909), *61* (2), 1909: 407 (Delaware Bay); Proc. Acad. nat. Sci. Philad., *62* (2), 1910: 470 (Maine, Mass., and New Jersey); Tracy, 40th Rep. R. I. Comm. inl. Fish., 1910: 61 (breeding season, nos., Rhode Island); Fowler, Proc. Acad. nat. Sci. Philad., *64* (1), 1912: 57 (Virginia); Denis, J. biol. Chem., *16*, 1913–14: 390 (blood chemistry); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 337, pl. 20, pl. 55, fig. 5, pl. 68, fig. 1 (descr., anat., Halifax to Carolinas); Halkett, Check List Fish. Canada, 1913: 12, 42 (listed, Gulf St. Lawrence to Virginia); Nichols, Abstr. Linn. Soc. N. Y., 1913: 91 (New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (1), 1913: 74, 162, 168, 417; *31* (3), 1913: 737 (breeding season, food, Woods Hole); Kendall, Proc. Portland Soc. nat. Hist., *3* (1), 1914: 12 (Maine locals.); Welsh, in Bigelow, Bull. Mus. comp. Zool. Harv., *58*, 1914: 111 (Seguin I., Maine, 25 fath.); Fowler, Copeia, 13, 1914: 2 (New Jersey); Proc. Acad. nat. Sci. Philad., *66* (2), 1914: 353 (Delaware); Copeia, 27, 1916: 12 (New Jersey); Copeia, 31, 1916: 41 (New Jersey); Proc. Boston Soc. nat. Hist., *35*, 1917: 111 (Maine and Woods Hole); Latham, Copeia, 41, 1917: 17 (season, Long Island, New York); Huntsman, Trans. roy. Soc. Canad., (3) *12* (4), 1918: 63 (temp., Gulf St. Lawrence); Fowler, Occ. Pap. Mus. Zool. Univ. Mich., 56, 1918: 2 (New Jersey); Copeia, 68, 1919: 13 (season, New Jersey); Fowler, Proc. Acad. nat. Sci. Philad., *71*, 1920: 293 (New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 145 (New Jersey); Townsend, N. Y. zool. Soc., 25th Annu. Rep. (1920), 1921: 126 (New York Bay); Huntsman, Contr. Canad. Biol. (1921), 3, 1922: 57 (Bay of Fundy and Passamaquoddy Bay); Breder, Copeia, 127, 1924: 28 (Sandy Hook Bay); Huntsman and Sparks, Contr. Canad. Biol., N. S. *2*, 1924: 102 (lethal temp.); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 9, 61, 64, 66, 83 (parasites); Scott, Contr. Canad. Biol., N. S. *2*, 1924: 131 (pathol. thyroid); Bigelow and Welsh, Bull. U. S. Bur. Fish. (1924), *40* (1), 1925: 58 (descr., ill., habits, Gulf of Maine); Battle, Trans. roy. Soc. Canad., (3) *20* (5), 1926: 127, 132 (effects of high temp.); Huntsman, Trans. roy. Soc. Canad., (3) *20* (5), 1926: 202, 203 (lethal temp.); Breder, Zoologica N. Y., *4* (5), 1926: 244 (listed); Manter, Illinois biol. Monogr., *10* (2), 1926: 8, 110 (trematode parasites); Nichols and Breder, Zoologica N. 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NE U. S., 1929: 16 (diagn.); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 30 (descr., ill., Atlant. Coast Maryland, Chesapeake Bay); Bere, Contr. Canad. Biol., N. S. 5, 1930: 426 (copepod parasites, Passamaquoddy Bay); Chaisson, Contr. Canad. Biol., N. S. 5, 1930: 477 (effects of fresh water, Passamaquoddy Bay); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (common names, listed, Virginia to Maine); Lutz, Amer. J. Physiol., *94*, 1930: 136 (effects of adrenalin on auricle); Marshall, Amer. J. Physiol., *94*, 1930: 7 (excretion); Huntsman, Contr. Canad. Biol., 7 (4), 1931: (4) 34 (heart physiol.); Lutz, Biol. Bull. Woods Hole, *61*, 1931: 94 (nerves, action of adrenalin); Smith, Amer. J. Physiol., *98*, 1931: 285 (ref. to Marshall, 1930); Breder, Copeia, 1932: 31 (Block Island); Nicholls, Contr. Canad. Biol., N. S. 7, 1933: 449 (gastric mobility); Contr. Canad. Biol., N. S. *8*, 1933: 139 (temp. effects); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 21 (descr., ill., range); Daniel, Elasmobranch Fishes, 1934: 9 (external form); Parker, Annu. Rep. Woods Hole oceanogr. Inst. (1933), 1934: 27 (color changes); Gudger, J. Morph., *57*, 1935: 99 (maxillary respiratory curtains, by ref. to Rand, 1907); Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 50, 51 (diagn., ill., Nova Scotia); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324 (in Key); Smith, Biol. Rev., *11*, 1936: 52, 62, 67 (osmotic pressure); Vladykov, Nat. canad., *63* [(3) 7], 1936: 213 (descr., ill., egg case); Breder and Nichols, Copeia, 1937: 182 (meas. egg case); Fowler, Proc. Acad. nat. Sci. Philad. (1937), *89*, 1938: 304 (New Jersey); Breder, Bull. N. Y. zool. Soc., *41*, 1938: 28 (season, New York Harbor); Merriman and Warfel, Trans. 9th N. Amer. Wildl. Conf., 1944: 234 (nos. Long Island Sound); Bull. Bingham oceanogr. Coll., *11* (3), 1948: 134, 148, 155, 157 (common names, sizes, nos., season, off Connecticut and Rhode Island).

Raia[149] *eglanteria* (in part) DeKay, Zool. N. Y., 4, 1842: 373 (*R. eglantiera* Lesueur 1824 included, equals *R. erinacea* Mitchill 1815); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 512 (*R. eglantiera* Lesueur 1824 included, equals *R. erinacea* Mitchill 1815); Gill, Proc. Acad. nat. Sci. Philad. (1861), Addend., 1862: 61 (*R. eglantiera* Lesueur 1824 included, equals *R. erinacea* Mitchill 1815); Duméril, Hist. Nat. Poiss., *1*, 1865: 532 (*R. erinacea* Mitchill 1815 included, also *R. eglantiera* Lesueur 1824, equals *R. erinacea* Mitchill 1815); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 462 (*R. erinacea* Mitchill 1815 included).

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Summer Skate, Wilson, Bull. U. S. nat. Mus., 158, 1932: 412 (copepod parasite, Woods Hole).

Probable Synonyms:

Raia diaphanes (in part) Storer, Mem. Amer. Acad. Arts Sci., N. S. *9*, 1867: 240, pl. 39, fig. 1; Fishes Mass., 1867: 264, pl. 39, fig. 1 (*R. erinacea* probably included).

Not *Raja eglanteria* Bosc 1802, in Lacépède, Hist. Nat. Poiss., 4° Ed., in Buffon, Hist. Nat., *2*, 1802: 104, 109, pl. 4, fig. 2.

Not *Raja diaphanes* Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 478 (equals *R. eglanteria* Bosc 1802; see p. 176).

Not *Raia diaphanes* DeKay, Zool. N. Y., 4, 1842: 366, pl. 67, fig. 218 (equals *R. ocellata* Mitchill 1815: see p. 251).

Not *Raja erinacea* Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 176, pl. 13 (a *Psammobatis*, renamed *extenta* by Garman [Mem. Harv. Mus. comp. Zool., *36*, 1913: 356], SE coast S. Amer.).

ADDENDUM TO *RAJA ERINACEA*

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At the time this volume went to press we were conducting an intensive study of *Raja erinacea*. Since the results of our work were not sufficiently advanced for full

149. Also spelled *Raja*.

publication in the Bulletin of the Bingham Oceanographic Collection and hence were not available to the authors of this volume, it was suggested that a summary of our findings to date, in the form of an ADDENDUM, would be useful. Although our studies have been carried on intermittently since 1943 and intensively in 1950, it is apparent that much of the life history of the Little Skate still rests on highly tentative ground, and therefore some of the conclusions put forth below remain to be confirmed, modified, or disproved by further observation and study.

Our results have been derived chiefly from a study of collections obtained monthly, or even more frequently, on a year-round basis from commercial draggers working off the southern New England Coast, particularly in Block Island and Long Island Sounds; in 1950 over 15,000 specimens were examined in detail. We have also been fortunate in having large outdoor tanks and laboratory facilities available to us at the U. S. Fish and Wildlife Service Station at Milford, Conn., through the generous cooperation of Victor L. Loosanoff.

In adult specimens, mating takes place throughout the year. This is clearly indicated both by the sperm plugs in the uterus and by fresh wounds at the fundus of the uterus, the latter being inflicted during copulation by the scimiter-shaped cartilage or "sentinel" of the clasper. In our samples to date, not less than 30 % of the adult females have shown wounds of this sort and a figure as high as 70 % has been recorded in one sample; in general, then, at any time during the year a rough average of 50 % of the adult females show fresh and often severe uterine lacerations—incontrovertible evidence of recent mating. Since copulation is probably effected at times without so wounding the female, it is a fair assumption that mating takes place frequently throughout the year. Sperm are stored in large numbers in the convolutions of the shell gland, as demonstrated by sectioning; we have no idea of the viability of sperm under these conditions, but it would not seem to be a matter of importance in the reproduction of this species in view of the frequency of mating. Indeed, perhaps there should be a revision of the general conception that sperm are "stored" in the shell glands of other species of Skates for the purpose of future fertilization; at least in *erinacea*, the whole female genital tract apparently contains sperm so consistently that it is no wonder that some find their way into the convolutions of the shell gland, a level which they must attain to accomplish fertilization.

Fertilization in adult females, as well as the production and laying of egg cases, takes place the year around. However, there are two periods when egg-laying is at a maximum, as judged by the percentage of pregnant fish in our samples. From late October to early January this figure averages between 30 and 50 % and has run as high as 59 % in one sample of Block Island Sound fish. Again in June and July, 25–30 % of the adult females from these waters are pregnant. In other months of the year less than 25 % are pregnant, a rough average for these "off" months for Block Island Sound fish being 10 %, with the lowest level of production coming in August and September. The same general pattern obtains in Long Island Sound samples, with peaks of 10–15 % pregnancy in the November–January and June–July periods and

considerably lower percentages of pregnancy in other months of the year; in these latter waters the percentage of pregnancy is always much lower than that in Block Island Sound fish. There is considerable variation from sample to sample, but in general the above pattern is remarkably consistent. We believe that the seasonal nature of breeding as outlined is the true situation, and we have much evidence to show that this picture does not arise from the vagaries of sampling by commercial fishing vessels—i. e., the tendency to fish possible spawning grounds of Skates in certain seasons (June–July and November–January) and to avoid those grounds in other months. Incidentally, in this regard the percentage of females with uterine wounds shows no striking correlation with the seasonal nature of productivity, although there may be a slight increase in the percentage two to four weeks before the peaks of productivity.

Ovulation takes place in both ovaries at approximately the same time, and the formation of the egg case by each of the two shell glands begins before either of the eggs has reached that level in its passage down its respective oviduct. By the time the cases are approximately $^1/_4$–$^1/_3$ formed, single eggs enter each after being much elongated in passing through the shell gland. Following the completion of egg-case formation, activity in the right arm of the genital tract invariably precedes that in the left arm. Thus, while eggs are always prepared for laying in pairs, the right egg descends and reaches the uterus first and is laid slightly in advance of the left egg (two exceptions out of thousands examined); we have detected no anatomical difference to account for this phenomenon. At one end the egg case always has two long straight tendrils, at the other end two shorter tendrils whose terminal portions are likely to be recurved; the end with the longer tendrils is laid down first by the shell gland. As a result of aquarium experiments and palpating techniques, we find that egg cases are formed and laid in a surprisingly short period of time, the entire process in June and July occurring in 48–72 hours. In the winter months the process is undoubtedly slower, and a female may retain fully formed egg cases for as much as three weeks. It appears that a few eggs in each ovary become ripe at approximately the same time and that these are laid in pairs at intervals from as little as five days to several weeks in the early summer production peak. Thus one of our aquarium fish laid four pairs of egg cases between June 7th and July 12th, 1950. Whether a mating is requisite for the fertilization of each successive pair of eggs or whether one copulation may serve to effect fertilization in several successive pairs of eggs is not known, since we had both sexes in our experimental tanks. Following the period of egg-laying, it appears likely that the whole genital tract undergoes somewhat of a regression, probably prior to building up the ovaries to a condition where they once again contain ripe eggs (*vide infra*). On the other hand, adult males carry sperm continuously at all times of year from the onset of maturity to death.

In our tank experiments, 12 females produced 65 egg cases between May 30th and July 12th, 1950, an average of over three pairs per fish. Of these 65 egg cases, only 10 (15 %) were found to contain living embryos; the others were either infertile or failed to survive past an early stage of development. This low percentage may have

been due to tank conditions, but it is interesting that it compares almost exactly with the results obtained by Clark[1] with *R. brachyura* kept in aquaria at Plymouth. These data suggest the possibility that in nature not more than 10–25 % of the eggs laid are fertile or develop beyond an early stage. In this connection, exceptions to the rule that each egg case contains only a single egg or embryo in this species are rare. From the many specimens we have examined we have found two eggs in a single egg case twice, and four eggs in one case once; all three anomalies were detected in pregnant fish, and in each instance the matching egg case was empty.

Hatching of eggs laid in the May–July period and maintained under aquarium conditions took place from November 29th, 1950 to January 1st, 1951, that is, five to six months after they were laid. This is probably the shortest time in which hatching takes place in nature, since the water temperatures in the aquaria were somewhat above those of the normal environment over the entire period and since eggs laid in June and July would be subject to optimum temperatures for the fastest development in these waters. Those laid in the November–January period probably take considerably longer to reach hatching. It seems probable that the eggs of *R. erinacea* take a minimum of six months and up to nine months or more after laying to arrive at the hatching stage in nature.

At hatching, Skates from Long Island Sound waters are 9.5–10.0 cm in total length and the yolk in the abdomen is still apparent. As this time the tip of the tail has a fine, distinctively pigmented, whip-lash elongation which disappears after a few days; thus the distance from the base of the second dorsal to the end of the tail is 1.4–1.5 cm at hatching and only 0.925–0.950 cm several weeks later when this filamentous piece has sloughed off. It seems quite possible that this 5 mm elongation is directly concerned with hatching; in short, it may be comparable in function to the egg-tooth in birds and similar devices in some Amphibia. Within the egg case before hatching the Skate is oriented so that its head points toward the end of the case possessing the long straight tendrils. The transverse margin of the case at this end is straight and sometimes frayed, and the two broadly convex surfaces of the case meet approximately 5 mm from the margin to form a flat area at that end. It is *via* the separation of the two surfaces of the egg case in this area that the Skate escapes, and after hatching this marginal area resembles an envelope which has been opened by a sharp paper cutter. Indeed, the opening through which the fish has emerged would not be detected by casual observation. Before hatching, the tail is curled around in a broad arc so that its tip is above the head and extends into the region which later becomes slit for the emergence of the young fish. It seems probable from observation and inference that the fine extension of the tail acts like a flagellum and eventually wears the case open in the slit-like manner described above. Apertures in the tendrils, through which the water presumably circulates freely, are present before hatching; apparently these "respiratory slits" do not exist at the time the egg is laid and we do not know at precisely what stage of development they appear.

1. J. Mar. biol. Ass. U. K., N. S. *12*, 1920: 577–643.

Determination of growth rates and ages at different lengths after hatching presents a major problem. Obviously the analysis of length-frequency curves is fraught with difficulty in a fish which breeds on a year-round basis, even though the species has peaks of productivity in June–July and November–December. Study of the hard parts by sectioning and clearing techniques is also unrewarding, although examination of whole vertebrae after subjecting them to various treatments shows considerable possibilities for age determination. The return of tagged fish has been too limited to be of use in checking growth estimates, and aquarium fish have not provided any data. Furthermore, we have taken relatively few small individuals in our collections. Piecing together all the fragmentary information at our disposal, it seems probable that this species grows at an average rate of 8–10 cm a year for the first three years following hatching and more slowly thereafter. Thus a 20 cm Skate might be 1–1.5 years old, a 30 cm individual 2–3 years of age, a 40 cm Skate 3–4 years, a 45 cm fish 4–5 and possibly 6 years, and a 50 cm individual 6–7 and perhaps 8 years old. Specimens above 50 cm are comparatively rare and the great majority are males; the largest we have recorded is 54 cm. In monthly samples of Block Island Sound fish the length-frequency curves show the peak of abundance to be between 43 and 46 cm; above this point the curve falls away very steeply, thus indicating a high mortality rate after the fish are approximately five years old.

In general, female specimens are adolescent in the range between 32 and 43 cm; we have found fish up to 42.5 cm which were still immature, as judged by the shell gland, size of the uterus and condition of the ovaries, and we have found fully mature individuals as small as 36 cm. Males tend to reach adolescence at a somewhat greater size, the general range being from 36 to 45 cm; we have found immature males as large as 44 cm and fully mature males at 37 cm.

With respect to the average length and weight of adolescent and fully mature males and females, there appear to be significant differences between the Long Island and Block Island Sound populations:

	Adolescent females	*Adolescent males*	*Mature females*	*Mature males*
Long Island	38.4 cm	40.0 cm	42.4 cm	43.1 cm
	344 g	338 g	475 g	455 g
Block Island	42.0 cm	42.2 cm	45.8 cm	46.4 cm
	462 g	422 g	596 g	587 g

These figures represent yearly averages, and it is abundantly clear from them that either the Long Island Sound fish mature earlier than those from Block Island Sound or they grow more slowly and perhaps mature at approximately the same age as their counterparts to the east. We suspect that the latter alternative is the true situation.

Continuing our comparison of samples of trawl-net catches from the two areas,

we find that in Long Island Sound the majority of Skates range from 39–44 cm, with a few up to 47 cm in length. In the Block Island Sound samples the majority of fish fall between 42 and 48 cm with a few from 49–54 cm. In short, on an average the Long Island Sound *erinacea* of both sexes are adolescent at a lesser length and mature at a lesser length than their Block Island Sound counterparts; further, the peaks of length-frequency curves of fish from Long Island Sound are consistently a good 3 cm less than the peaks of those from Block Island Sound samples, and the Long Island Sound fish never attain the uppermost size limit of the largest ones from Block Island Sound, i. e., up to 48–54 cm. Considering this, and the previously mentioned fact that Long Island Sound *erinacea* are much less prolific, plus the fact that there is apparently no substantial intermingling between the two areas, it is rather clearly indicated that these are two essentially separate populations. The one from Long Island Sound we think of as poor, slow-growing, and relatively unproductive; the other, from Block Island Sound and seaward, we think of as the more normal, healthy, faster-growing, and comparatively productive population. Further evidence to support this contention is found in the fact that at all times of year comparable trawl hauls in Block Island and Long Island Sounds yield many more fish in the former area than in the latter; the former appears to be a flourishing population, the latter a sparse and rather unsuccessful one. Comparing the Block Island and Long Island Sound populations further, the sex ratios show peculiar differences. In Block Island Sound, males dominated the adult population (60–80 %) throughout 1950 (except for March–April), while in Long Island Sound, females dominated the adult population (70 %) throughout 1950 (except in March–April). In both areas the females dominated the immature population (at least 70 %) with few exceptions. Morphometric comparisons between the two populations will almost certainly show significant differences, and apart from occasional strays and a minor amount of intermingling at the adjacent boundaries of the two areas, the Long Island and Block Island Sound *erinacea* may well be considered two separate races.

In this connection, if this species should be fished hard commercially for fish meal or other purposes (Vitamin A is low, approximately 100 units per gram of liver oil), we have every reason to believe that the catch-per-unit-of-effort would decline rapidly; in short, the Little Skate would not be capable of yielding a steady supply over long periods. Leaving the Long Island Sound population out of consideration because of its paucity, the Block Island Sound fish command our attention because they are probably more representative of this species over its whole range. From what we have indicated previously of growth rates, sharp mortality above 46 cm, age at maturity, percentage of fertilization, survival to hatching, etc., it would appear that this species has no great capacity to increase the present size of the total population; it is clearly not a fish which is subject to marked fluctuations in abundance from natural causes. Correspondingly, a reduction in the numbers of sexually mature fish by increased fishing effort would shortly lead to a reduction in the number of young that would be added to the stock each year. If only one out of every four to ten egg cases

reaches a hatching stage (*vide supra*), it is clear that in nature each female would have to lay more than the maximum observed by us in aquarium experiments (eight) to maintain the stock. If the stock is to be held at the same level, each female must produce two offspring which attain sexual maturity. We suspect that mortality after hatching is relatively low, but if our rough estimate of the percentage of eggs which reach hatching is of the right order of magnitude, this would mean that each female would have to lay a general minimum of 10–20 eggs; actually, each one probably lays 20–30 eggs under average conditions. Whether this occurs consecutively, once maturity is reached, or whether there is a resting period between successive ovulations, we do not know. However, we strongly favor the latter alternative. We find many large-sized females with reduced shell glands and ovaries, the majority of which are probably in a resting stage prior to another ovulation. Also, the ripe ovary never contains at one time more than about three eggs that have reached or are approaching the laying size. We suspect, therefore, that a typical female produces on the order of five to six eggs over a laying period, say the June–July peak, and that the metabolic strain of producing these large-yolked eggs is such that the female requires a number of months to build up to a condition where she can lay another comparable batch of eggs. According to our estimates, each female would have to have at least two or three such laying periods in order to maintain the population, and some may have as many as four. From our knowledge of the age at maturity, the rate of growth of these older fish (roughly 4–5 cm a year as judged from length-frequency and other data), the sharp mortality rate at greater sizes, and from our estimate that there are a number of months between laying periods, we derive a time schedule which would allow for three or four such laying periods in the life of the average female *erinacea*. Because of the nature of this reproductive pattern, we do not believe that the stock could stand intensive fishing without showing a sharp reduction in the size of the population in a relatively short period and a consequent drop in the catch-per-unit-effort, a situation which has occurred in other elasmobranch fisheries.

Marking experiments have yielded little information due to the low percentage of return, which we attribute chiefly to the fact that the $1/2''$ disc tags we used were not obvious enough to catch the attention of the fishermen as the Skates were shovelled overboard as trash or barrelled in bulk for fish meal or other uses. Out of approximately 600 *erinacea* tagged in June 1946 in the Block Island Sound area, only five fish were returned: one in July 1946; two in August 1946; another in February 1947; and the last in April 1947. All of these recaptures were within five miles or less of the original point of release except the last, which was taken approximately 50 miles to the west, off Herod Point on the north shore of Long Island. If we can judge by such meager returns, it would seem that this species undertakes no extensive migrations in this region, although the specimen captured in Long Island Sound would indicate occasional straying between the Block Island and Long Island Sound populations. However, there does appear to be some evidence of definite seasonal offshore and onshore movements in the Block Island Sound region involving distances of 3–5 miles and upward. This

evidence, from conversations with local fishermen and from trawl catch samples, indicates that in general the bulk of the Skates move inshore in the spring, offshore in the middle or late summer, inshore again in the late fall and offshore again in mid-winter. Our data on relative abundance in different seasons and at different localities, as judged by trawl catch samples, correlates well with this apparent movement. Note, too, that the inshore movements fit well with the spawning peaks in the late spring and early winter mentioned above. From this and other evidence we think it probable that this species of Skate customarily spawns in relatively shallow water (15 fathoms and less) on a hard sandy bottom. Observations on aquarium fish indicate that the eggs are usually at least partly buried in the sand.

Turning to the matter of food eaten by Skates in this region, the amphipod, *Leptocheirus pinguis*, is the dominant element, constituting anywhere from a third to a half of the volume of the stomach contents at all times of year; *Cancer irroratus* follows at one-fifth, and *Crago septemspinosus* at a tenth.

Although there is considerable variation in the weight at any given length, in general Block Island Sound fish weigh 0.5 lb. when they are $12^3/_4$–13 in. long, 0.75 lb. at 15 in., 1.0 lb. at $16^1/_4$ in., 1.25 lb. at 18 in., and 1.5 lb. at $19^1/_4$ in. The largest fish, about $21^1/_4$ in., weighed roughly 2.0 lbs.

Since hermaphroditism appears to be rare in elasmobranch fishes, we record herewith the capture of a specimen of *R. erinacea* which shows this phenomenon in rather extreme form. This fish, taken by a commercial dragger on July 18, 1950, about three miles south of Fisher's Island, N.Y., was 41.5 cm in length and 408 g in weight. On the left side this individual was a fully developed male with large testis, vas deferens, and a completely adult and apparently functional clasper with the typical prominent clasper gland at its base. On the right side there was a tiny and abortive clasper, barely recognizable as such, an ovary which was characteristic of an adolescent female, a quite well developed shell gland and an oviduct which was characteristic of mature female *erinacea*.

The work here reported would not have been possible without the generous cooperation of many individuals, and we make grateful acknowledgment to the following: Captains Ellery F. Thompson, Joseph Roderick and Harold McLaughlin trawling out of Stonington; Andrew, Bonaventura, and Gabriel Gargano out of New Haven; and the entire staff of the Bingham Oceanographic Laboratory.

Raja fyllae Lütken 1887

Figures 39, 40

Study Material. Female, 452 mm long, trawled off southwestern Ireland (Lat. 51°37′ N, Long. 11°56′ W) between 610 and 640 fathoms (British Museum [Natural History]); adult male, 438 mm long, taken from southern slope of Georges Bank, 420–480 fathoms, July 12, 1952, by Woods Hole Oceanographic Institution.

Distinctive Characters. R. fyllae resembles *R. erinacea* and *R. ocellata* in that its

FIGURE 39. *Raja fyllae*, female, 452 mm long, from off SW Ireland (British Museum [Natural History]). *A* Ventral view of pelvics. *B* Nostrils and mouth, about 1.3×. *C* Dorsal view of posterior part of tail, about 1.3×.

snout is short and obtuse and the midbelt of its disc and the upper surface of its tail are rough with rather large thorns in several irregular rows, the thorns not much larger in any one row than in any of the others. But *R. fyllae* differs noticeably from the other two species in its longer tail. Young specimens of *R. fyllae*, in which there is still only a single row of thorns along the tail, are separable by their longer tails from all other western North Atlantic Skates of similar thorn pattern, with the exceptions of *R. bathyphila*, *R. garmani* and young specimens of *R. senta*. The more obtuse snout of *R. fyllae* with its pale lower surface sets it apart from *R. bathyphila*, and there is no danger of confusing *R. fyllae* with *R. garmani* at any stage in growth, so characteristic is the color pattern of the latter. But the only character we have found to separate newly hatched *R. fyllae* from newly hatched *R. senta* (now that the former has been encountered within the range of the latter) is the color of the tail, which is plain-colored in young *fyllae* but pale cross-barred in young *senta*.

Description. Proportional dimensions in per cent of total length. Female, 452 mm long, from Lat. 51°37′ N, Long. 11°56′ W (British Museum [Natural History]).

Disc: extreme breadth 49.3; length 40.8.

Snout length: in front of orbits 9.5; in front of mouth 10.5.

Orbits: horizontal diameter 4.0; distance between 3.3.

Spiracles: length 3.1; distance between 6.4.

Mouth: breadth 5.8.

Nostrils: distance between inner ends 5.3.

Gill openings: lengths, 1st 1.3; 3rd 1.3; 5th 1.2; distance between inner ends, 1st 12.6; 5th 6.7.

First dorsal fin: vertical height 2.2; length of base 5.1.

Second dorsal fin: vertical height 2.0; length of base 6.2.

Pelvics: anterior margin 10.6.

Distance: from tip of snout to center of cloaca 39.8; from center of cloaca to 1st dorsal 45.7; to tip of tail 60.2; from rear end of 2nd dorsal base to tip of caudal 3.1.

Interspace between: 1st and 2nd dorsals 0.0.

Disc 1.2 times as broad as long, conspicuously obtuse in front but decreasingly so with growth, the maximum anterior angle in front of spiracles 130–140° in small specimens, 115–125° in adults; tip of snout marked by a low prominence. Anterior margins of pectorals nearly evenly convex in young specimens but weakly concave in larger females and considerably more so in adult males at level of spiracles, some being definitely indented;[2] outer corners broadly rounded, posterior margins evenly and moderately convex, posterior corners broadly rounded with curvature extending to axils. Axis of greatest breadth about 70 % of distance rearward from tip of snout toward axils of pectorals. Tail with lateral folds confined to posterior one-third and widening

2. A male of this shape, from Lat. 63° 30′ N, Long. 54° 25′ W, is pictured by Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: pl. 22, fig. a).

toward tip; its length from center of cloaca to first dorsal greater than distance from center of cloaca to tip of snout by a distance 1.5–3.0 times as long as horizontal diameter of orbit in very young to medium-sized specimens and at least as long as distance from center of cloaca to snout in adults; total length of tail from center of cloaca to tip about 1.3–1.6 times as great as distance from cloaca to snout in large specimens; juveniles with tail perhaps averaging a little longer.[3]

Small specimens up to 90–100 mm long with a single median row of 30–40 large thorns on upper surface from nuchal region to first dorsal; 1–3 thorns on each shoulder; 1–2 close behind orbit, with as many immediately anterior to it; a few smaller

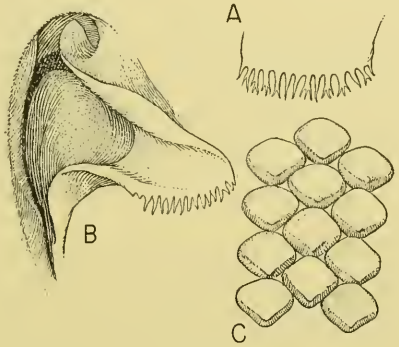


FIGURE 40. *Raja fyllae*, same specimen as in Fig. 39. *A* Posterior margin of nasal curtain, about 2.8×. *B* Nostril, about 3.6×. *C* Upper teeth near middle of jaw, about 7.2×.

ones near tip of rostral ridge; mid-dorsal row less regular with growth, 2–3 additional rows developing irregularly along either side of it (no single row more conspicuous than others); thus, typical adults are thorny along whole mid-dorsal belt of disc as well as along upper surface of tail (Fig. 39), but some have midback thornless or nearly so immediately posterior to shoulder region;[4] additional large thorns also developing with growth over shoulder region as a whole, around orbits, and in 2–3 irregular rows along rostral ridge; also a few developing in space between orbits in some specimens. The outer posterior margins of the pectorals as well as areas of varying extent on either side of the mid-dorsal belt continue thornless, but the anterior marginal regions become conspicuously thorny by maturity in males, as is also the case in some females but not in others (var. *lipacantha*). A patch of large thorns also develops on the inner part of

3. The relative length of the tail appears to vary considerably in half-grown and adult *R. fyllae*, to judge from published photographs (Clark, Rep. Fish. Bd. Scot. [1926], 1, 1926: cf. pl. 22, fig. a with pl. 24, figs. a, b).
4. Described as a separate variety, *lipacantha*, p. 198. See Clark (Rep. Fish. Bd. Scotl. [1926], 1, 1926: pl. 24, figs. a, b) for photographs of an adult male and female with thorn pattern of this sort.

each pectoral on some females but not on males. The skin of the disc and tail is also rough with small prickles on small specimens, but extensive areas on the median and posterior parts of the disc and on the upper surface of the tail are largely smooth in adults, apart from the thorns. The pelvics are naked except for prickly patches on the central parts of the posterior lobes, the dorsals are sparsely prickly. Alar spines of mature males in two to three rows. Lower surface naked in adults of both sexes, but described as prickly along margins of tail in newly hatched specimens.[5]

Snout anterior to orbits about 2.4 times as long as distance between orbits, its length in front of mouth about 2.0 times as great as distance between exposed nostrils. Diameter of orbit about 1.3 times as long as spiracle, distance between orbits about as great as length of orbit or a little less. Distance between first gill openings about 2.4 times as long as distance between exposed nostrils, distance between fifth gill openings 1.3 times; first gill openings slightly longer than fifth and about $^1/_4$ the breadth of mouth. Nasal curtain deeply fringed with simple, bifid, or trifid lobelets; expanded outer (posterior) margin of nostrils also fringed. Mouth moderately arched centrally, the outer ends more or less concealed when closed.

Teeth in 30–38 series, closely crowded in quincunx; those of young, and of females to maturity with a circular base and low, blunt, conical cusp; those of adult males with sharp cusp.

First and second dorsal fins confluent, the second a little the larger (in specimen examined) and continuous with caudal membrane, the latter about half as long as second dorsal. Pelvics moderately concave, the marginal excavation having one rather noticeable subtriangular projection; anterior margin about 55–60 % as long as distance from its own origin to rear tip of pelvic; posterior lobe strongly convex outwardly and weakly scalloped; rear tips broadly rounded. Claspers of maturing males extending about half of distance from axil of pelvics toward first dorsal.

Anterior rays of pectorals reaching about 80 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface ash gray to chocolate brown, either uniform or somewhat clouded with paler and darker. Young with more or less pronounced darker brown spots, pale-ringed in var. *lipacantha* (see discussion below). Lower surface white, grayish white, pale gray or light fawn color, uniform or with sooty patches on pelvics and on axils of pectorals in roughly symmetrical pattern.

Remarks. A separate varietal name, *lipacantha*, has been proposed[6] for representatives of *R. fyllae* from the Skagerrak, where, according to descriptions, the young specimens are more finely prickly than those of the typical form; adults have a sparser development of thorns along the midbelt of the back, and the anterior margin is definitely notched in the adult male.[7] *R. fyllae* of the western Atlantic are the typical form, and it is these that come within the scope of the present account.

5. Clark, J. Mar. biol. Ass. U. K., *12*, 1922: 626.
6. By Jensen, Vidensk. Medd. naturh. Foren. Kbh., 1905: 233.
7. Clark, Rep. Fish. Bd. Scot. (1926), *1*, 1926: cf. pl. 24, fig. a with pl. 22, fig. a.

Size. The smallest specimens seen were 72.5 and 80 mm long, suggesting a length (apart from the embryonic caudal filament) of about 70 mm at hatching. Some males, and presumably females also, may mature at a length no greater than 450–460 mm;[8] others, however, do not mature until they are somewhat larger, for the claspers on a male 483 mm long are described as not fully formed.[9] The greatest length that we have found recorded for *R. fyllae* is 543 mm, but the maximum size attained is probably somewhat greater.

Developmental Stages. An egg capsule, probably of this species, taken in the Folden Fjord on the west coast of Norway at 250–285 meters, was smooth-shelled and black, 40 mm long (exclusive of horns) by 24 mm broad, with the longer horns 32 mm and the shorter pair 21 mm long.[10]

Newly hatched specimens[11] differ chiefly from half-grown and adults in having less thorny discs and the thorns along the midbelt of the back in a single regular row (p. 197).

Habits. Of the habits of *R. fyllae* we know only: that the stomach of a small specimen contained small crustaceans (copepods, amphipods, mysids); that nearly all specimens taken thus far have been from 148–983 fathoms (mostly 230–500 fath.), the greatest depth recorded for it being 1,121 fathoms (2,050 m);[12] and that they came from localities where the bottom temperature was between 3 and 5.5° C (37.4 and 41.9° F).

Range. Barents Sea, Bear Island, western Spitzbergen, Murman Coast, northern Norway, Denmark Strait west of Iceland, and Davis Strait off West Greenland; south in the east to the southern part of the Norwegian Basin, inward along the Norwegian trough to the Skagerrak between Norway and Denmark, Faroe Channel, the Atlantic Ocean west and south of Iceland and the slope westward from the Straits of Gibraltar; in the west to the southern slope of Georges Bank. The range of *R. fyllae* appears to be defined by its preference for a narrow temperature range of a few degrees above the freezing point of salt water (see above) and by restriction to at least moderately deep water.

Occurrence in the Western North Atlantic. Records of its capture in the western Atlantic have been confined to four stations in the Greenland side of Davis Strait, Lats. 63°30′ to 66°49′ N and to one station on the southern slope of Georges Bank. Since it appears to be confined in its northward dispersal to water of Atlantic influence, there is no reason to expect it north of the Davis Strait Ridge. But a path would appear to be open for it, so far as temperature is concerned, around the upper part of the southern slope of the Ridge at depths of 400–600 fathoms. Watch should be kept for it on the slope off Labrador and Newfoundland and southward at appropriate depths.

8. See Clark (Rep. Fish. Bd. Scot. [1926], *1*, 1926: pl. 24, fig. a) for photograph of an adult male of this size as calculated from its breadth.
9. Jensen, Vidensk. Medd. naturh. Foren. Kbh., 1905: 234.
10. Nordgaard, Tromso Mus. Skr., *1* (4), 1925: 9.
11. See Clark (J. Mar. biol. Ass. U. K., *12*, 1922: 624) for description and photographs of a very small specimen.
12. For depth and temperature records for *R. fyllae*, see especially Hofsten (K. svenska VetenskAkad. Handl., *54* [10], 1919: 83) and Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 42).

Synonyms and References:

Raja circularis Collett, Nyt Mag. Naturv., *29*, 1885: 119 (listed fishing banks off Jaederen, W. Norway, also Skagerrak off Arendal, S. Norway, 200 and 370 fath.); Rep. Norweg. Fish. Invest., *2* Pt. 2 (3), 1905: 5 (meas., Finmark, also Arendal, S. Norway).

Raja fyllae[13] Lütken, Vidensk. Medd. naturh. Foren. Kbh., 1887: 1, pl. 1 (descr., meas., cf. other species, ill., Davis Str., 80 fath.); Vidensk. Medd. naturh. Foren. Kbh., 1891: 32 (descr., meas., Davis Str., 235 and 289 fath., Denmark Str., 426 fath.); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 69 (descr. after Lütken, Davis Str.); Lütken, Danish Ingolf Exped., *2* (1), 1898: 4, pl. 2 (descr., ill., depth, temp., Denmark Str. and W. Greenland); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (depth, range); Knipowitsch, Annu. Mus. zool. Acad. St. Pétersb., *5*, 1900: 245 (listed, Murman Coast); Lönnberg, Swed. Polar Exped., Fishes, in Rev. int. Pêche, Spb., *2* (4), 1900: 11 (listed, Spitzbergen; not seen); Knipowitsch, Annu. Mus. zool. Acad. St. Pétersb., *6*, 1901: 82 (depth, temp., Spitzbergen and Murman Sea); Ehrenbaum, in Römer and Schaudin, Fauna Arctica, *2* (1), 1902: 142 (depths, Davis Str., Murman Sea, N. of Bear I., Spitzbergen); Knipowitsch, Exped. Wiss. Prakt. Unters. Murman Küste, *1*, 1902: 592 (depths, Murman Coast; in Russian, with German abstr.); Collett, Arch. Math. Naturv., *25* (2), 1903: 3 (refs., hist., descr., depth, range, off N. Norway); Knipowitsch, Annu. Mus. zool. Acad. St. Pétersb., *8* (2), 1903: 155 (listed, W. Spitzbergen); Collett, Forh. Vidensk-Selsk. Krist., 7, 1905: 114 (*R. circularis* Collett 1885, 1905 and *R. falsavela* Smitt 1895 considered ident. with *R. fyllae*, range, depth, temp.); Ehrenbaum, Wiss. Meeresuntersuch., Abt. Helgoland, N. S. *7*, 1905: 65 (size, thorn pattern, depth, NW. of Bear I., 400 m); Jensen, Vidensk. Medd. naturh. Foren. Kbh., 1905: 227 (depth, SW. from Faroes; see also under *R. fyllae* var. *lipacantha*); in Schiødte and Hansen, Zool. Danica, *2*, Fisk., 12, 1907: 329, pl. 32, fig. 1 (descr., ill., range); Berg, Faune Russie, Poiss., *1*, 1911: 104 (refs., descr., meas., Barents Sea and Spitzbergen; in Russian); Murray and Hjort, Depths of Ocean, 1912: 433 (depths, S. of Faroes and W. from Gibraltar); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 322 (descr.); Jensen, Mindeskr. Steenstrup Fods. Kbh., *2* (30), 1914: 27, 38 (refs., depths, temp., W. Greenland, chart of distrib.); Hofsten, K. svenska VetenskAkad. Handl., *54* (10), 1919: 83 (locals., depths, temp.); Clark, J. Mar. biol. Ass. U. K., *12* (4), 1922: 624 (descr., meas., color, stom. contents, depth, NW. of Scotland); Nordgaard, Tromsø Mus. Skr., *1* (4), 1925: 9 (photo egg case, Folden Fjord, Norway); Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 41, pl. 22, pl. 23, fig. 2 (descr., size, discuss., range, photos, juv. and adult); Koeford, Rep. Sars N. Atlantic Deep Sea Exped., 1910, *4*, 1927: 27 (depths, temps., W. of Ireland and W. of Gibraltar); Clark, Fauna Ichthyol. Cons. int. Explor. Mer, 1931: pl. not numbered (descr., size, range, depth, ills., egg case, juv., adult); Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 43 (meas., egg capsules, distr., Greenland).

Raja falsavela Smitt, Hist. Scand. Fish., *2*, 1895: 1112, fig. 319 (ill., juv., off Arendal, Norway, 370 fath., but not descr. or refs.).

Raja fyllae var. *lipacantha* Jensen, Vidensk. Medd. naturh. Foren. Kbh., 1905: 233 (descr., color, size, depth, Skagerrak); Berg, Faune Russie, Poiss., *1*, 1911: 108, footnote (Russian); Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 42, pl. 23, fig. b, pl. 24 (descr., color, range, depth, photos, discuss.); Faune Ichthyol. Cons. int. Explor. Mer, 1931: pl. not numbered (descr., range, photos, Skagerrak).

Doubtful Synonym:

Raja circularis Günther, Challenger Rep., *22*, 1887: 8 (Faroe Channel, ident. doubtful because dark below).

Not *Raia circularis* Couch, Cornish Fauna, 1838: 53.

Not *Raja falsavela* Bonaparte, Icon. Faun. Ital., 1841: pl. not numbered; equals *R. circularis* Couch 1838; see Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 34).

Raja garmani Whitley 1939

Rosetted Skate, Leopard Skate

Figures 41, 42

Study material. One hundred and twenty specimens, male and female, 85 to 432 mm long, from various localities between the offings of southern New England

13. Also spelled *Raia*.

FIGURE 41. *Raja garmani*. Left, Male, 398 mm long, from off North Carolina, Lat. 36°46′ N, Long. 74°41′ W, 57–97 fathoms (Harv. Mus. Comp. Zool., No. 34762). Right, Female, 401 mm long, from off Montauk Point, Long Island, New York (Harv. Mus. Comp. Zool., No. 36315).

and Palm Beach, Florida, in U. S. National Museum and Harvard Museum of Comparative Zoology (including type).

Distinctive Characters. The conspicuous dark rosettes on the upper surface provide the readiest field mark for specimens of this species from shortly after hatching, since no other Skate of the western Atlantic is marked in this way. Among Skates of the eastern Atlantic, *R. garmani* falls nearest to *R. naevus* Müller and Henle 1841 in shape of disc, length of tail, and general distribution of thorns; but it differs from *R. naevus* in that its back is thornier (especially when adult), the skin of the disc is naked apart from the thorns (largely prickly in *R. naevus*), and the color pattern is different. It has no close counterpart among Skates of the Pacific Coast of America.

Description. Proportional dimensions in per cent of total length. Male, 398 mm

long, from Lat. 36°46′ N, Long. 74°41′ W (Harv. Mus. Comp. Zool., No. 34762). Female, 401 mm, from 70 miles SSW of Montauk Point, Long Island, New York (Harv. Mus. Comp. Zool., No. 36315).

Disc: extreme breadth 55.3, 54.6; length 44.2, 44.0.
Snout length: in front of orbits 9.5, 9.0; in front of mouth 10.3, 11.0.
Orbits: horizontal diameter 3.6, 4.2; distance between 3.3, 3.6.
Spiracles: length 2.9, 3.2; distance between 6.0, 6.2.
Mouth: breadth 5.9, 5.7.
Nostrils: distance between inner ends 6.3, 6.0.
Gill openings: lengths, 1st 1.8, 2.1; 3rd 1.8, 2.1; 5th 1.0, 1.7; distance between inner ends, 1st 12.3, 13.0; 5th 5.4, 7.2.
First dorsal fin: vertical height 2.9, 1.7; length of base 6.0, 5.1.
Second dorsal fin: vertical height 2.4, 1.5; length of base 6.1, 4.9.
Pelvics: anterior margin 11.3, 11.2.
Distance: from tip of snout to center of cloaca 40.5, 40.7; from center of cloaca to 1st dorsal 43.0, 45.7; to tip of tail 59.5, 59.3; from rear end of 2nd dorsal base to tip of caudal 3.5, 3.0.
Interspace between: 1st and 2nd dorsals 0.9, 0.8.

Disc 1.2–1.3 times as broad as long, noticeably obtuse in front, the maximum anterior angle in front of spiracles about 112–115° in mature specimens; anterior margins weakly concave just posterior to tip of snout and again opposite spiracles; otherwise rather strongly convex, the contour about the same in males as in females; outer corners broadly rounded, posterior corners less so; posterior margins strongly and evenly convex. Axis of greatest breadth about 70 % of distance back from tip of snout toward axils of pectorals. Tail with narrow dermal folds along posterior $^2/_3$ to $^4/_5$; its length from center of cloaca to origin of first dorsal about 1.2 times as great as, to tip of tail about 1.5 times as great as, distance from snout to cloaca both in adults and in young after loss of filamentous prolongation.

Smallest specimens (85–125 mm long) with a few small thorns on rostral ridge; three larger ones in front of each orbit, a few along inner margin of orbit, and 2–3 close behind latter; 1–3 on each shoulder; a row of about 33–35 thorns along midline of disc and tail to first dorsal, and 1–2 thorns between first and second dorsals. Larger specimens have a row of thorns along each margin of the rostral cartilage (none on tip of snout), 2–5 in the space between the orbits, a row around the inner margin of the orbit, several in front of it and 1–3 behind, a patch of about 3–6 thorns on each shoulder, 1–3 irregular rows along the midbelt of back and tail on either side, but the median row is partially lost with growth in some cases. On small specimens the upper surface of the disc and tail is largely prickly in addition to the thorns, but on large ones the upper surface is naked apart from the thorns except for a prickly patch that persists beside each eye and sometimes a few prickles on the outer parts of the pectorals. Pelvics prickly in young; posterior parts of pelvics also prickly in females

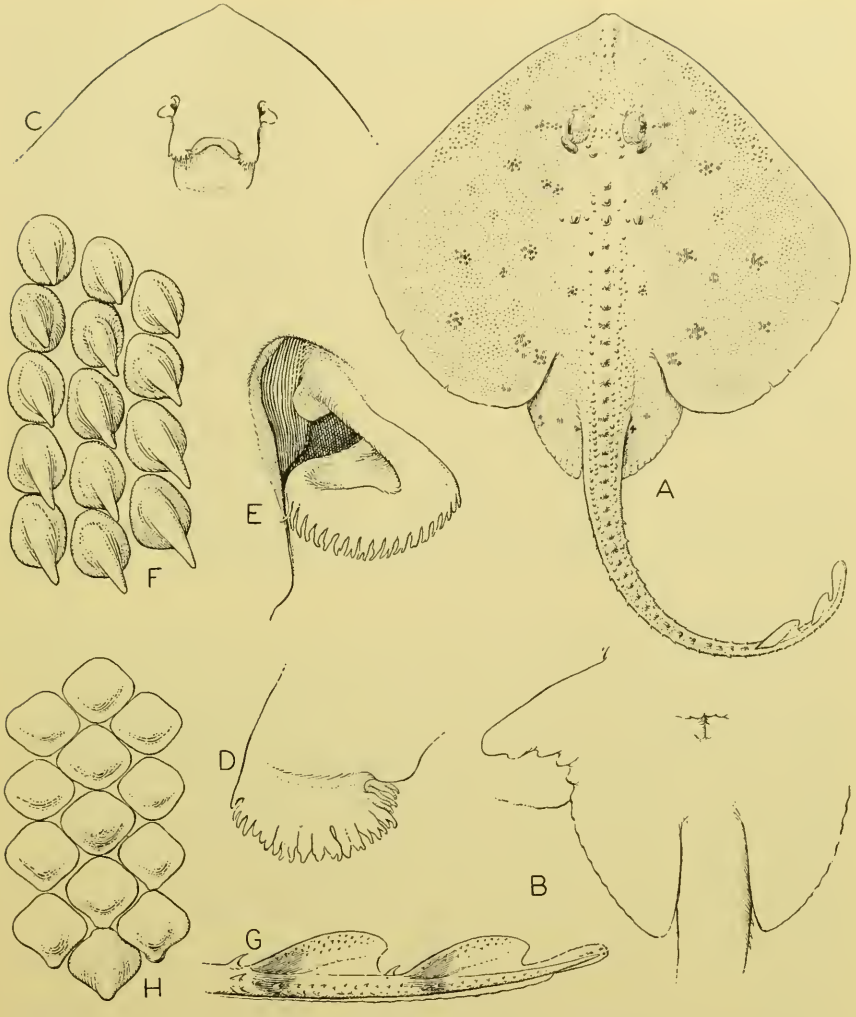


FIGURE 42. *Raja garmani*. *A* Female, 173 mm long, from off southern New England, Lat. 40°08′ N, Long. 71°36′ W (Harv. Mus. Comp. Zool., No. 34767), to illustrate juvenile color pattern and dermal armature. *B* Ventral view of pelvics of female illustrated in Fig. 41. *C* Ventral view of anterior part of head of male illustrated in Fig. 41, about 0.6×. *D* Margin of nasal curtain of same, about 4.2×. *E* Outer posterior margin of nostril of same, about 5.2×. *F* Left-hand upper teeth of same near middle of jaw, about 14×. *G* Side view of posterior part of tail of female illustrated in Fig. 41, about 0.6×. *H* Upper teeth of same from center of jaw, about 14×.

but smooth or nearly so in mature males. Alar spines of maturing males in two rows, perhaps more in some cases. Lower surface smooth.

Snout in front of orbits 2.4–2.9 times as long as distance between orbits, its length in front of mouth about 1.6–1.7 times as great as distance between exposed nostrils. Distance between orbits about as long as horizontal diameter of orbit in young but only about 70–80 % as long in adults; orbit about 1.3 times as long as spiracle. Distance between first gill openings 2.0–2.2 times as long as distance between exposed nostrils, the distance between fifth gill openings 0.86–1.2 times as long; first gill openings 1.2–1.7 times as long as fifth and about 30–37 % as long as breadth of mouth. Nasal curtain and posterior (outer) margin of nostrils deeply fringed. Mouth considerably more arched centrally in adult males than in females or young.

Teeth $\frac{46-52}{42-50}$; those of females and of young males closely set, in quincunx, the older rows evenly rounded (as a result of wear), the younger rows with faintly indicated cusp; teeth of adult males spaced more loosely in more nearly transverse series, with blunt-tipped conical cusp.

Interspace between first and second dorsals about 15 % as long as base of first dorsal, with 1–2 thorns.[14] Caudal membrane posterior to base of second dorsal about $^2/_3$ as long as base of first dorsal. Pelvics rather deeply concave outwardly, strongly scalloped around the concavity; anterior margin about 48–56 % as long as distance from its own origin to rear tip of pelvic; anterior lobe narrow with rounded tip, including only 1–2 radials besides the first stout one; posterior lobe with weakly convex outer margin and narrow tip.

Anterior rays of pectorals reaching about $^3/_4$ the distance from level of fronts of orbits toward tip of snout.

Color. Upper surface pale buff or brown freckled with small spots, darker or paler, and conspicuously marked with dark rosettes, each consisting of a group of six or more dark brown or black spots surrounding a central one; rosettes arranged in symmetrical pattern on disc and along tail, with one at origin of each dorsal fin. On specimens only 85 mm long, one rosette is already visible on either side of the shoulder region, one opposite and a little behind each eye, and one or two on the tail. Lower surface white or pale yellow.

Size. This is one of the smaller members of the genus, males maturing at a length of only about 400 mm,[15] no doubt females as well. A specimen of 85 mm is the smallest seen.

Developmental Stages. Neither the egg cases nor its newly hatched young have been seen.

Habits. Little is known of its habits. It appears to be restricted to depths greater

14. The type specimen (Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 18. fig. 2) has three distinct dorsal fins on the tail. See Schnakenbeck (Zool. Anz., *140*, 1942: 88–90) for description and photo of a specimen of the European *R. clavata* with an accessory dorsal fin close behind the pectoral girdle and for references to earlier accounts of similar abnormalities.

15. The claspers of a male 395 mm long in our Study Material already extend more than halfway from the level of the axils of the pelvics toward the tip of the tail; they appear to be fully developed or nearly so.

than 35–40 fathoms. Temperatures recorded for captures of *R. garmani* have fallen between 5.3° C (41.6° F) and 9.8–10° C (49–50° F) in the northern part of its range to as high as 15° C (59.1° F) in the southern part. The known salinities at which it has been taken have also fallen within a narrow range: 33.8 ‰ off Block Island to 35.3 ‰ off Chesapeake Bay.

Range. Western North Atlantic from southern Florida to the offing of southern New England in Long. 69°22′ W, mostly on the outer part of the continental shelf and the upper part of the continental slope.

Details of Occurrence. R. garmani has been taken between the 30 and 290 fathom contours[16] in the vicinity of the Tortugas; off the Florida Keys and Palm Beach, Florida; off North and South Carolina; off Chesapeake and Delaware bays, and off southern New England, a total of about 20 locality records. The fact that it has never been reported among other Skates that are taken in abundance from the slopes of Georges or the Scotian banks locates the eastern boundary of its regular range near the longitude of Cape Cod or about 70° W. In the opposite direction, it appears that it does not cross the Straits of Florida, for it was not represented among the extensive series of Skates collected in Cuban waters by the Atlantis in 1938–1939.

Along southern New England it is one of the most abundant of the Skates found offshore. Thus we observed it in 21 out of 44 hauls made in 47–67 fathoms between Long. 71°15′ and 71°54′ W,[17] in 12 out of 49 hauls in 41–240 fathoms between Long. 67°10′ and 72°20′ W.[18]

Synonyms and References:

Raja[19] *ornata* Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 235 (descr., depth, off Alligator Key, Florida, and off S. Carolina; considered possibly a variety of *R. ackleyi* Garman 1881); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1882: 877 (descr. after Garman, 1881; off S. Carolina and Florida); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed, off Atlant. Coast N. Amer.); Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 26 (descr., but not ill., pl. 7, fig. 24 in vol. *31*); also, Mem. Harv. Mus. comp. Zool., *22*, 1896 (depth, off Alligator Key, Florida, and off S. Carolina); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 70 (descr., off S. Carolina and Florida); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, off S. Carolina and Florida); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (depth, range); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (listed, Alligator Key, Florida); Roule, Bull. Inst. océanogr. Monaco, 243, 1912: 20 (cf. *R. ackleyi*); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 336, pl. 18, fig. 2 (descr., depth, off Florida); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 271 (descr., color, size, depth, off C. Lookout, N. Carolina); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 26 (listed, N. Carolina and Florida); Schroeder, Bull. Boston Soc. nat. Hist., *58*, 1931: 3 (depth, off Block Island); Fowler, Proc. Acad. nat. Sci. Philad., *89*, 1937: 297 (off C. May,

16. Depths of capture (where recorded) are: off Nantucket and Marthas Vineyard, 44–150 fath.; off Block Island, 50 fath.; off New York, 70 fath.; off Chesapeake Bay, 93 fath.; off northern North Carolina, about 30–70 fath.; Lat. 36° 46′ N, Long. 74° 41′ W, 57–90 fath.; off Cape Lookout, 100–111 fath.; off South Carolina, 60–142 fath.; off southern Florida and the Tortugas, 127–290 fath.
17. Hauls by the dragger Eugene H., January 27 to February 3, 1950. In each of 11 hauls only one specimen was caught, but in other hauls as many as 20 to 50.
18. Hauls by the Albatross III. Only one specimen was taken in the 26 hauls made east of Long. 70° W (in 69° 22′) and none were caught in 14 hauls made in depths shoaler than 41 fathoms.
19. Spelled *Raia* by some authors.

New Jersey); Longley and Hildebrand, Pap. Tortugas Lab., 535, 1941: 4 (depth, off Tortugas, Florida); Hildebrand, Copeia, 1941: 222 (listed, N. Carolina).

Raia ackleyi ornata Goode and Bean, Smithson. Contr. Knowl., *31*, 1895: pl. 7, fig. 24; also Mem. Harv. Mus. comp. Zool., *22*, 1896: pl. 7, fig. 24 (ill.).

Raja garmani Whitley, Aust. Zool., *9*, 1939: 248 (*garmani* proposed to replace *ornata* Garman, preoccupied by *ornata* Agassiz, L. [Poiss. Foss., *3*, 1843: 372, pl. 37, fig. 34] for a fossil Skate).

Raja hyperborea Collett 1878

Arctic Skate

Figures 43, 44

Study Material. Males, 103 and 445 mm wide, and female, 138 mm wide, from Faroe Channel, 607 fathoms (British Museum [Natural History]); six specimens, male and female, 600–850 mm long, including two with fully formed claspers, from Ivigtut Fjord (about Lat. 61° N) near Julianehaab, Southwest Greenland (Harv. Mus. Comp. Zool., Nos. 36548 to 36553).

Distinctive Characters. R. hyperborea resembles *R. jenseni* (p. 216), *R. lintea* (p. 232), and *R. radiata* (p. 255) in its noticeably short tail and in its mid-dorsal row of stout thorns which extends from the nuchal region to the first dorsal fin, the thorns close posterior to the pelvic girdle being much larger than any other thorns farther rearward along the tail. But it differs from *R. radiata* by its more numerous (22–31) mid-dorsal thorns; from *R. lintea* by its fewer thorns (47–51 in *R. lintea*) and by its shorter and more obtuse snout (cf. Fig. 43 with 49); and from *R. jenseni* by its fewer teeth (about 38–44 series in upper jaw in *R. hyperborea*, 58–66 series in *R. jenseni*) and by the development with growth of large thorns on the posterior parts of the pectorals and on the outer anterior parts of the disc (prickly only in *R. jenseni*). Young specimens resemble young *R. fyllae* in general appearance, but they are separable from them by their shorter tails, more pointed snouts and lozenge-shaped discs. The subarctic range of *R. hyperborea* in the Atlantic lends special interest to the fact that it seems clearly separable from all of the Skates that have been reported from the Bering Sea-Northeast Siberian region. Among these it appears closest to *R. rosispinis* Gill and Townsend 1897 in number and arrangement of large thorns. But the skin of the disc (mostly smooth in *R. hyperborea* apart from thorns) is described as largely prickly in *R. rosispinis*.[20] Nor does *R. hyperborea* have any close counterpart in boreal-subantarctic latitudes of the South Atlantic, as have *R. radiata* and *R. spinicauda*.

Description. Proportional dimensions in per cent of total length. Female, 810 mm (Harv. Mus. Comp. Zool., No. 36549). Male, 850 mm (Harv. Mus. Comp. Zool., No. 36553), from Ivigtut Fjord, Southwest Greenland.

Disc: extreme breadth 76.5, 75.0; length 55.6, 54.3.

Snout length: in front of orbits 14.3, 13.5; in front of mouth 13.1, 14.6.

Orbits: horizontal diameter 3.1, 3.0; distance between 6.0, 6.5.

20. The original account of *R. rosispinis* (Gill and Townsend, Proc. biol. Soc. Wash., *11*, 1897: 231) is brief and without illustration.

FIGURE 43. *Raja hyperborea*. *A* Male, 850 mm long, from Tunugdliarfik Fjord, West Greenland (Harv. Mus. Comp. Zool., No. 36552). *B* Lateral view of posterior part of tail of same, about 0.5×. *C* Dorsal view of tail of same, about midway of its length, about 0.5×. *D* Female, 785 mm long, from Tunugdliarfik Fjord, West Greenland (Harv. Mus. Comp. Zool., No. 36551).

Spiracles: length 2.3, 2.8; distance between 10.1, 10.1.
Mouth: breadth 12.5, 12.3.
Nostrils: distance between inner ends 10.4, 11.0.
Gill openings: lengths, 1st 1.2, 1.2; 3rd 1.4, 1.5; 5th 1.2, 1.3; distance between inner ends, 1st 19.7, 18.8; 5th 13.8, 13.6.
First dorsal fin: vertical height 2.0, 2.1; length of base 3.8, 3.9.
Second dorsal fin: vertical height 1.6, 1.8; length of base 3.7, 4.0.
Pelvics: anterior margin 12.0, 12.0.
Distance: from tip of snout to center of cloaca 57.5, 57.1; from center of cloaca to 1st dorsal 31.3, 32.5; to tip of tail 42.5, 42.9; from rear end of 2nd dorsal base to tip of tail 2.8, 2.2.
Interspace between: 1st and 2nd dorsals 0.9, 1.4.

Disc lozenge-shaped, about 1.3–1.4 times as broad as long; maximum anterior angle in front of spiracles about 90–105° in females and in young males but about 110° in mature males; tip of snout not projecting noticeably; anterior margins of pectorals weakly convex close anterior to level of eyes in females, considerably more strongly convex in mature males; outer corners abruptly rounded, posterior corners somewhat more broadly rounded, especially in males; posterior margins nearly straight along forward two-thirds and gently convex along rearward third. Axis of greatest breadth 66–71 % of distance rearward from snout toward level of axils of pectorals. Tail with moderately broad lateral folds extending its entire length; its length from center of cloaca to first dorsal about 77–82 % (small specimens) and about 54–57 % (large) as great as distance from center of cloaca to tip of snout; on adults, total length of tail from center of cloaca 74–75 % as great as distance from center of cloaca to tip of snout.

Specimens of all sizes usually with 2–4 large thorns on each shoulder, one close to inner end of spiracle and another close in front of orbit; one on posterior part of orbital ridge and 1–3 smaller ones on some specimens; a varying number of small to medium thorns on anterior part of rostral ridge; a single mid-dorsal row of conspicuous thorns on strongly radiate bases extending from nuchal region nearly to first dorsal fin, the largest on disc and the smallest along posterior part of tail, numbering about 30–31 on small specimens (11–15 anterior to axils of pelvics) but decreasing to about 24–27 on half-grown specimens and larger (10–12 anterior to axils of pelvics); also 1–3 irregular rows of thornlets developing along either side of anterior part of tail; median areas and anterior margins of pectorals also becoming more or less thorny; interspace between the two dorsals with 1–2 thorns on small specimens but not on large ones. In small specimens, skin of disc largely prickly, the region between and anterior to eyes continuing so to maturity, but half-grown specimens and larger with extensive naked areas on either side of mid-dorsal ridge, abreast of spiracles and eyes, over inner parts of pectorals, and along outer posterior margins; pelvics smooth in small and half-grown specimens, but central parts of posterior lobes of adults with a few small thorns and prickles, more conspicuous in some males than in females; dorsals either

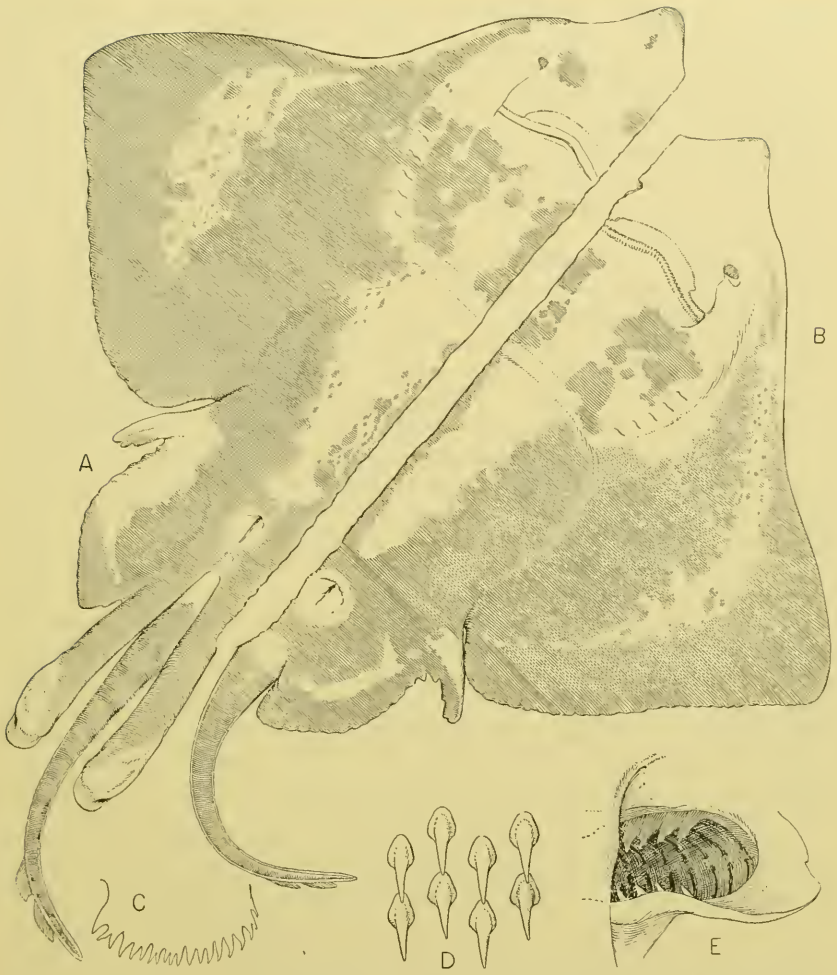


FIGURE 44. *Raja hyperborea*. *A* Male illustrated in Fig. 43. *B* Female illustrated in Fig. 43. *C* Nasal curtain of same female, about 1.5×. *D* Upper teeth of same female near center of jaw, about 3.9×. *E* Nostril of male, illustrated in Fig. 43, about 2.9×.

smooth or with a few minute prickles; sides of tail, from base to tip, with a conspicuous belt of closely crowded prickles increasing in density rearward and outlined above by small thorns in some specimens but separated from mid-dorsal row of large thorns by

a more or less naked band. Alar spines of adult males in two rows, about 15 in each row. Lower surface entirely smooth.

Snout in front of orbits about 4.4–4.6 times as long as distance between orbits, its length in front of mouth about 1.3 times as great as distance between nostrils. Orbits in young about 80 % as long as distance between them and about 1.8 times as long as spiracle; in adults, about 47–51 % as long as distance between them and about 1.1–1.3 times as long as spiracle. Nasal curtain deeply fringed; expanded posterior (outer) margin of nostril either smooth or slightly jagged. Mouth slightly more bowed in adult males than in females.

Teeth $\frac{38-44}{38-44}$, alike in both sexes, long and needle-pointed on broad bases and loosely spaced in transverse series.

Dorsal fins close to tip of tail, about equal in size, the apex of first dorsal pointed (a characteristic feature), that of second dorsal more rounded; the two dorsals either confluent or separated by a short interspace, sometimes with 1–2 intervening thorns in small specimens but not in adults. Caudal membrane so low as to be distinguished only with difficulty. Pelvics deeply concave outwardly, the indentation scalloped in some specimens but not in others; anterior margin about 45–55 % as long as distance from its own origin to rear tip of pelvic; anterior lobe slender, with rounded tip, including only two radials besides the first stout one; posterior lobe moderately convex, its tip narrowly rounded or subangular.

Anterior rays of pectorals extending forward about 55–70 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface dark mouse gray, dark blue gray, or dark brown, either uniform or irregularly marked with small indefinite rounded spots, light or dark; outer posterior margins of pectorals dusky, margins of pelvics narrowly so. Lower surface of medium-sized and large specimens variegated white and sooty in variable patterns, some chiefly white below with more or less symmetrical dark markings, others chiefly dark with white areas confined to head, and still others intermediate. For typical patterns, see Fig. 44. Small specimens either lack dark markings at first[21] or may already show various small blotches on disc, pectorals and tail.[22]

Relationship to Other Species. It has been suggested that *R. badia* Garman 1899, taken at 1,270 fathoms in the Gulf of Panama (Lat. 7°05′ N, Long. 79°40′ W) by the Albatross, may be identical with *R. hyperborea*.[23] However, our own examination of the type (and unique) specimen of *R. badia* shows that, while it agrees closely in its dermal armature with *R. hyperborea*, its axis of greatest breadth is much farther rearward (only a little anterior to the level of the axils of its pectorals) than in *R. hyperborea*, and the

21. Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* (30), 1914: 21.

22. The two small specimens we have seen are plain-colored below, but they are so evidently stained that we cannot say whether they were white or uniformly gray originally. One 180 mm long from the Faroe-Shetland Channel was yellow below, the pelvics and cloaca tinged with violet (Koefoed, Rep. Sars N. Atlantic Deep Sea Exped., *4* [1], Zool., 1927: 24), and one 160 mm long from the Barents Sea is described as yellowish-white below, marked with dark spots behind the mouth, along the margins of the trunk, on the posterior portions of the pectorals, and on the tail (Thielemann, Wiss. Meeresuntersuch., Abt. Helgoland, N. F. *13*, Heft 2, 1922: 197).

23. Berg (Faune Russie, Poiss., *1*, 1911: 103) includes *R. badia* with query in the synonymy of *R. hyperborea*.

inner edge of each of its nostrils bears a narrow barbel-like lobe directed outward and rearward, a character that is not duplicated in any other Skate that we have examined.[24]

Size. The length shortly after hatching (irrespective of whatever traces may persist of the embryonic caudal filament) appears to average about 160–180 mm.[25] A male 598 mm long is still immature, its claspers extending only a little beyond the tips of its pelvics; but one 850 mm long is in breeding condition, judging from the size of the claspers, which reach about halfway along the tail. The largest female recorded was 860 mm long.[26]

Developmental Stages. The egg cases average about 1.5 times as long as broad, exclusive of the horns; the egg cases measured have ranged from 81–125 mm in length (apart from horns) by 56–80 mm in breadth.[27] In general appearance they resemble those of *R. radiata* and their margins are similarly flanged. However, their blackish brown to golden yellow shells lack the rough transverse wrinkles with which those of *R. radiata* are usually sculptured, but they are described as covered with silk-like hairs when newly laid.

Habits. R. hyperborea is at home in polar temperatures from hatching to maturity and its eggs are incubated successfully and regularly in water as cold as 0° C (32° F) or colder; so far it has not been taken in water warmer than 1.5° C.[28] Furthermore, it appears to be confined to depths greater than 100 fathoms (shoalest recorded capture 120 fath.) even in the subpolar part of its range; it occurs chiefly in depths greater than 150–200 fathoms, and it has been taken at a depth of 1,309 fathoms.[29] In the Norwegian Basin, where the icy bottom water of polar origin is overlaid by a much warmer layer, the upper boundary for *R. hyperborea* falls about at the transition between the two water masses, i. e., at about 300 fathoms. But its failure to come into shoal water in subpolar situations, such as the Greenland fjords, cannot be explained on the basis of temperature.

The nature of its teeth suggests that *R. hyperborea* feeds on active prey, which is confirmed by the fact that the stomach of a specimen taken west of Spitzbergen contained 50 large pelagic amphipods (*Euthemisto libellula*), fragments of an Arctic prawn

24. These barbels are pictured by Garman (Mem. Harv. Mus. comp. Zool., *24*, 1899: pl. 6, fig. 2) though not mentioned by him.

25. The smallest free-living specimen recorded measured 160 mm (Thielemann, Wiss. Meeresuntersuch., Abt. Helgoland, N. F. *13*, Heft 2, 1922: 195), but another of 180 mm still showed traces of the yolk sac (Koefoed, Rep. Sars N. Atlantic Deep Sea Exped., *4* [1], Zool., 1927: 24).

26. Vanhöffen, in Drygalski, Grönl. Exped. Gesellsch. Erdkunde Berlin, *2* (1), 1897: 127, as *R. radiata*; Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* (30), 1914: 23.

27. For more detailed accounts of the egg cases, some positively identified because they were taken from the mother and another by the embryo it contained, see Jensen (Mindeskr. Steenstr. Fods. Kbh., *2* [30], 1914: 25–26; Spol. Zool. Mus. Hauniensis, 9, 1948: 41–43), and Thielemann (Wiss. Meeresuntersuch., Abt. Helgoland, N. F. *13*, Heft 2, 1922: 194, 197).

28. Our specimens from Southwest Greenland (p. 206), and one reported earlier from Ilua Fjord, near Cape Farewell, were from localities where the bottom temperature at the depth in question is probably below 1° C throughout the year, to judge from the readings that have been taken at Julianehaab and in two adjacent fjords (Krümmel, Handb. Ozeanogr., *1*, 1907: 455; Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* [30], 1914: 39). See Hansen (Rapp. Cons. Explor. Mer, 123, 1949: 8–12) for secular variations in temperature off West Greenland.

29. 142 fathoms (Barents Sea) to 1,309 fathoms (south of Jan Mayen) in the northeastern part of its range; 120 fathoms down to 260 fathoms in Greenland waters.

(*Hymenodora glacialis*), and three fishes, one of them more than a third as long (185 mm) as its captor (518 mm). Cephalopod fragments also have been found in its stomach.

Its egg cases have been collected in West Greenland waters, in the Barents Sea, and in the Norwegian Basin from midsummer to early autumn in temperatures ranging from 0.5–1.1° C and through the general depth range where the species occurs.

Range. Arctic waters tributary to the northern North Atlantic, south to the Scotland-Faroe-Iceland Ridge in the east and to southern Greenland in the west.

Details of Occurrence. Thus far, recorded captures of *R. hyperborea* have been for the eastern part of the Barents Sea (three stations), from northwest of Spitzbergen (one station), from south of Jan Mayen (one station), from the western, southern, and southwestern slopes of the Norwegian Sea, including the Faroe-Shetland Channel (about a dozen stations), and from the deep fjords along the west coast of Greenland from the southern extremity to as far north as Lat. 78°14′ N.[30] But it seems that it does not occur along West Greenland between about Lat. 61° and 69°13′ N or on the offshore fishing banks along this sector. It has not been reported from the American side of Davis Strait, but there appears to be no thermal barrier to its dispersal westward along the Baffin's Bay ridge or southward, perhaps even to the northeastern slopes of the Grand Banks. Therefore, watch should be kept for it along the shores of outer Labrador and Newfoundland, both in the deeper fjord-like bays and on the slope in the ice-chilled Labrador Current. It is not likely to penetrate the Gulf of St. Lawrence except as a stray, for the temperature of the deep trough of the latter below 125–150 fathoms is too high for it (4–5° C), while the overlaying layer of icy cold water (colder than 1–2° C) does not ordinarily extend down deep enough to more than touch the uppermost boundary of the ordinary depth range of this particular species.[31]

Synonyms and References:

Raja[32] *hyperborea* Collett, Vidensk. Selsk. Forh. Christiania (1878), 14, 1879: 7 (descr., meas., stom. contents, off NW. Spitzbergen, 459 fath.); Norske Nordhaus Exped., *3*, Fisk., 1880: 9, pl. 1, figs. 1, 2 (descr., ill., same specimen as Collett, 1879, off NW. Spitzbergen); Günther, Challenger Rep., *22*, 1887: 8, pl. 4 (descr., ill., between Scotland and Faroes, 400–600 fath.); Lilljeborg, Sverig. Norg. Fisk., *3* (2), 1891: 604 (*R. hyperborea* Collett 1879, cf. *R. hyperborea* Günther 1887, descr., food, depth, range); Goode and Bean, Smithson. Contr. Knowl., *30*, *31*, 1895: 28, pl. 9, fig. 28; also Mem. Harv. Mus. comp. Zool., *22*, 1896: 28, pl. 9, fig. 28 (descr. after Collett and Günther; ill. after Collett); Smitt, Hist. Scand. Fish., 2nd ed., *2*, 1895: 1111 (descr., ill., doubts if distinct from *R. radiata*); Lütken, Danish Ingolf Exped., *2* (1), 1898: 2 (descr., size, S. of Jan Mayen, 1,309 fath.; N. of Faroes); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 24 (*R. hyperborea* Collett 1879 cf. *R. hyperborea* Günther 1887); Lönnberg, Bih. svensk. VetenskAkad. Handl., *24* (4) 9, 1899: 34 (listed, Faroe Channel); Ehrenbaum, in Römer and Schaudin, Fauna Arctica, *2*, 1902: 142 (listed, off NW. Spitzbergen and Faroe Channel); Knipowitsch, Exped. Wiss. Prakt. Unters. Murman Küste, 1, 1902: 592 (listed, Murman Coast; in Russian, with German abstr.); Collett, Arch. Math. Naturv., *24* (2), 1903: 7 (refs., descr., meas., stom. contents, range, depth, off Vesteraalen, Norway); Knipowitsch, Annu. Mus. zool. Acad. St. Pétersb., *8* (2), 1903: 150, 151, 153, 155 (depth, W. of north. Spitzbergen and Barents Sea); Collett, Rep. Norweg. Fish. Invest., *2* (3), 1905: 10 (descr., meas., stom. contents, depth, refs., W. of Romsdalen, Norway,

30. See Jensen (Spol. Zool. Mus. Hauniensis, *9*, 1948: 38) for a list of localities along the west coast of Greenland.
31. For the distribution of temperatures in the deeper strata of the Gulf of St. Lawrence, see especially Bjerkan (Canad. Fish. Exped. [1914–1915], 7, 1919).
32. Also spelled *Raia*.

640 m); Medd. Norges Fisk. (1884–1901), *3*, 1905: 121 (Andenaes, Vesteraalen, Norway, 914 m); Pietschmann, Ann. naturh. (Mus.) Hofmus. Wien, *22* (4), 1907–1908: 296 (listed, NW. Greenland); Saemundsson, Skr. Komm. Havunders. Kbh., 5, 1909: 126 (E. of Langanes, Iceland, 455 fath.); Berg, Faune Russie, Poiss., *1*, 1911: 103, pl. 2 (refs., descr., ill., depth, Barents Sea; in Russian); Murray and Hjort, Depths of Ocean, 1912: 436, 437 (depths, temps., Norwegian Sea, Faroe-Shetland Channel); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 330 (descr. after Collett); Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* (30), 1914: 20 (descr., meas., egg cases, S. and NW. Greenland), 37 (range), 38, fig. 12 (chart of distrib.); Thielemann, Wiss. Meeresuntersuch., Abt. Helgoland, N. S. *13*, Heft 2, 1922: 193 (descr., meas., photo of egg case and embryo, depths, temps., Barents Sea); Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 30 (descr., egg case, refs., range); Koeford, Rep. Sars N. Atlantic Deep Sea Exped. (1910), *4* (1), 1927: 24 (descr., meas., Faroe Channel, 1,098 fath.); Clark, Faune Ichthyol. Cons. int. Explor. Mer, 1930: pl. not numbered (descr., ills., range); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 31 (descr., ill., after Collett, range); Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 31 (refs., descr., W. Greenland records).

Raja radiata Vanhöffen, in Drygalski, Grönl. Exped. Gesellsch. Erdkunde Berlin, *2* (1), 1897: 127 (descr., NW. Greenland).

Raja borea Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 24 (*R. borea*, n. sp. proposed for *R. hyperborea* Günther 1887, as distinct from *R. hyperborea* Collett 1879); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 330 (descr. after Günther, 1887[33]).

Not *Raja radiata* Donovan, Nat. Hist. Brit. Fish., *5*, 1807: pl. 114 (see p. 255).

Raja jenseni Bigelow and Schroeder 1950

Jensen's Skate

Figures 45, 46

Study Material. Male, 223 mm long, from the eastern slope of Georges Bank, Lat. 41°09′ N, Long. 66°02′ W, in 1,255 fathoms; female, 541 mm long, from the continental slope off southern New England, Lat. 39°35′ N, Long. 71°21′ W, in 1,043 fathoms; female, about 850 mm long, from the continental slope off Halifax, Nova Scotia, in 200 fathoms;[34] all in U. S. National Museum and all collected many years ago.

Distinctive Characters. R. jenseni resembles *R. hyperborea* closely in general appearance as well as in the arrangement of thorns on the head and shoulders and on the midline of the disc and tail. But it is quite sharply set apart from *R. hyperborea* at all ages in that it has 56–66 series of teeth in each jaw (38–44 in *R. hyperborea*); it lacks large thorns on the anterior margins and midposterior parts of the pectorals and on either side of the mid-dorsal ridge on the disc rearward from the shoulder region; also, thorns are lacking on the rostral ridge of adults.

Description. Proportional dimensions in per cent of total length. Male, 223 mm, from Lat. 41°09′ N, Long. 66°02′ W (U. S. Nat. Mus., No. 33457). Female, 541 mm, from Lat. 39°35′ N, Long. 70°21′ W (U. S. Nat. Mus., No. 35592, type).

33. Spelled *Raia*.

34. Caught from the fishing schooner AUGUSTA H. JOHNSTON, Captain G. A. Johnston. It is catalogued as being from Lat. 42° 37′ N, Long. 62° 55′ W, but the depth at which it was taken actually locates it as being taken a few miles farther north and closer inshore.

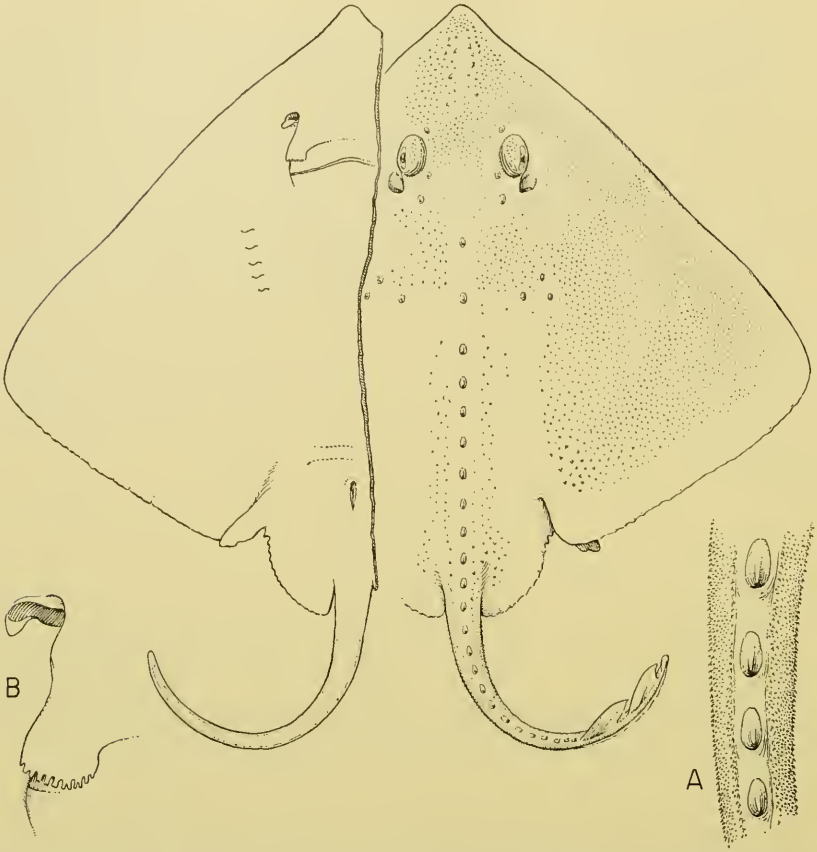


FIGURE 45. *Raja jenseni*, female, 541 mm long, from continental slope off southern New England, Lat. 39°35′ N, Long. 71°21′ W, 1,043 fathoms (U. S. Nat. Mus., No. 35592, type). *A* Upper surface of midsector of tail of same, about 1.2×. *B* Right-hand nostril and nasal curtain of young specimen illustrated in Fig. 46, about 2.3×.

Disc: extreme breadth 70.2, 81.3; length 53.7, 60.0
Snout length: in front of orbits 14.4, 15.5; in front of mouth 16.9, 16.3.
Orbits: horizontal diameter 4.4, 4.8; distance between 6.2, 6.6.
Spiracles: length 2.5, 2.8; distance between 10.6, 12.0
Mouth: breadth 12.5, 12.5.
Nostrils: distance between inner ends 12.8, –.
Gill openings: lengths, 1st 1.3, 1.3; 3rd 1.6, 1.5; 5th 1.0, 1.0; distance between inner ends, 1st 18.9, 21.6; 5th 14.0, 18.1.

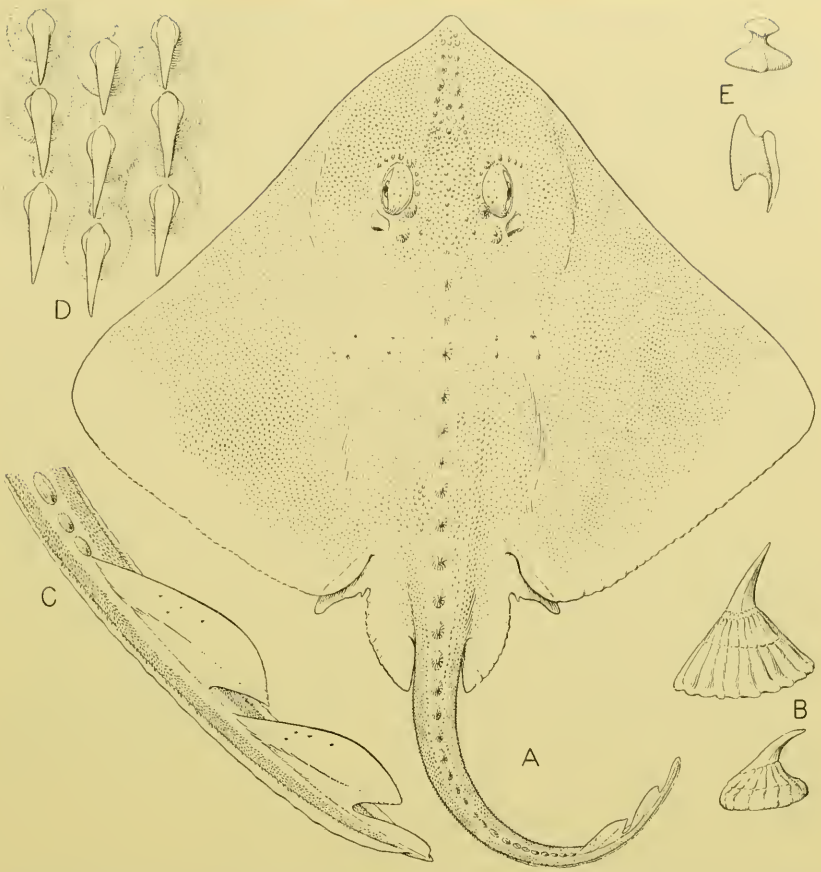


FIGURE 46. *Raja jenseni*. *A* Juvenile male, 223 mm long, from eastern slope of Georges Bank, 1,255 fathoms (U. S. Nat. Mus., No. 33457). *B* Thorn from head posterior to eyes (above) and from tail (below) of same, enlarged. *C* Posterior part of tail of larger female illustrated in Fig. 45, about 1.2×. *D* Upper teeth of same, about 12×. *E* Apical and lateral views of tooth, about 12×.

First dorsal fin: vertical height 1.7, 1.8; length of base 5.0, 5.4.
Second dorsal fin: vertical height 1.5, 2.0; length of base 5.2, 5.2.
Pelvics: anterior margin 10.7, 11.5.
Distance: from tip of snout to center of cloaca 51.5, 52.8; from center of cloaca to 1st dorsal 33.6, 32.5; to tip of tail 48.5, 47.2; from rear end of 2nd dorsal base to tip of caudal 3.9, 2.6.
Interspace between: 1st and 2nd dorsals 0.8, 0.9.

R. jenseni agrees so closely with *R. hyperborea* in proportional dimensions and in shape of disc and fins that detailed description in these respects would only be repetitious. There is a median row of 24–31 large thorns on conspicuously radiate bases from the nuchal region to the first dorsal fin, these becoming successively smaller and increasingly crowded rearward along the tail, the total number decreasing somewhat with growth;[35] four large thorns on each shoulder on smaller specimen, 2–3 on larger; one close to inner end of spiracle, one just in front of each orbit, and one close behind it; a row of several small thorns around inner anterior margin of orbit in young but not in older specimens; also on young, 2–3 rows of thorns of various sizes along rostral ridge which are shed progressively with growth; disc also generally rough with small prickles (in addition to the thorns) on small specimens except around posterior margins of pectorals; the snout, the region between orbits, the anterior margins of disc, a band across each pectoral, and a belt along either side of posterior part of mid-dorsal ridge continuing prickly with growth; pelvics prickly on inner part but without thorns (more or less thorny on *R. hyperborea*); first and second dorsals with a few small prickles; sides of tail with a dense prickly band from base to tip. Lower surface smooth.[36] Teeth 56–66 above and below on specimens counted, loosely spaced in transverse series, sharp-pointed in both sexes, as in *R. hyperborea* (cf. Fig. 46D with 44D).

Color. Upper surface (after many years' preservation in alcohol) plain light brown, either grayish or of chocolate hue, darker along margins of fins. Ground tint of lower surface brownish gray, grayish white, or perhaps pure white, but areas around cloaca and over inner parts of pelvics of small specimens dusky, these dark areas expanding over the abdomen with growth; outer margins of pectorals also brown in large specimens. Conditions in the related species, *R. hyperborea* (p. 210), suggest that the dark markings on the lower surface may be widely variable in *R. jenseni* also.

Remarks. R. jenseni was first reported and discussed as *Raja granulata* Goode and Bean,[37] and our earlier accounts of it[38] were under that same name. But it seems practically certain that the Skate for which the specific name *granulata* was proposed originally[39] and the specimen that was figured subsequently under that name by its describers[40] actually was a *Raja laevis* (p. 228).

Size. The largest specimen known (a female) was about 850 mm long (see Study Material), suggesting that its maximum size is about the same as that for *R. hyperborea.*

35. Thirty-one thorns in the median row in the smallest *R. jenseni* seen but only 24 or 25 in the half-grown specimen; a complete count could not be made for the largest specimen.
36. The largest of the three listed specimens (see Study Material, p. 213) was described earlier by us (Bull. Mus. comp. Zool. Harv., *68*, 1927: 246; Canad. Atlant. Fauna, 12[c], 1934: 29) under the name *R. granulata* Goode and Bean 1879 as having minute rounded tubercles sparsely sprinkled over the lower surface of the disc. Re-examination has shown, however, that Jensen's (Mindeskr. Steenstr. Fods. Kbh., *2* [30], 1914: 22, footnote) characterization of it as perfectly smooth below was correct; doubtless the supposed tubercles (no longer to be seen or felt) were merely grains of sand imbedded in the mucous. The specimen was in a good enough state to afford a detailed description when we first saw it, but it is now fragmentary.
37. Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* [30], 1914: 31.
38. Bull. Mus. comp. Zool. Harv., *68*, 1927: 246; Canad. Atlant. Fauna, 12[c], 1934: 29.
39. Goode and Bean, Bull. Essex Inst., *11*, 1879: 28.
40. Goode and Bean, Smithson. Contr. Knowl., *31*, 1895: pl. 9, fig. 30; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: pl. 9, fig. 30.

Developmental Stages. Neither the egg cases nor the newly hatched young of *R. jenseni* have been seen.

Habits. The localities and depths of capture indicate that *R. jenseni* lives at rather higher temperatures (3.6–3.9° C, or 38–39° F) than does *R. hyperborea*; that it is strictly a deep-water species, finding its upper limit at or below 200 fathoms, otherwise fishermen would almost certainly pick it up along the upper slopes of the Banks; and that its range almost certainly extends down to a depth of at least 1,200–1,300 fathoms.[41] The nature of its teeth suggests that it feeds chiefly on active prey such as small fishes and free-swimming crustacea, as its relative *R. hyperborea* is known to do.

Range. R. jenseni is known only from the offing of Halifax, Nova Scotia in 200 fathoms and from the lower part of the continental slope off Georges Bank and southern New England in 1,043–1,255 fathoms, at the localities listed (p. 213). But its range, if governed by distribution of water temperature (3–4° C, 37–39° F) at the considerable depths at which they have been taken, may well extend much farther south, for the bottom water is of about that temperature all along the lower part of the continental slope from the southeastern corner of the Newfoundland Banks to the offing of northern Argentina.

Synonyms and References:

Raja jenseni Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103*, 1950: 385 (descr., ill.).

Raja granulata Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* (30), 1914: 31 (off Halifax, N. Scotia, 42°37′ N, 62°55′ W, 200 fath., cf. *R. spinicauda*); Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *68*, 1927: 246 (descr., meas., same spec. as Jensen, 1914, off Halifax, Nova Scotia); Canad. Atlant. Fauna, 12e, 1934: 29 (descr., ill. of same specimen as in Jensen, 1914, and Bigelow and Schroeder, 1927, off Halifax, Nova Scotia; but LaHave Bank ref. is to *R. granulata* Goode and Bean 1879, equals *R. laevis* Mitchill 1817); Bull. U. S. Bur. Fish., *48*, 1936: 323, footnote (ref. to old record off Halifax, Nova Scotia); Vladykov, Nat. canad., *63*, 1936: 212, 228 (suggests *R. granulata* ident. with *R. hyperborea*).

Raja granulata (in part) Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51 (off Halifax, but ref. for LaHave Bank is to *R. granulata* Goode and Bean 1879, equals *R. laevis* Mitchill 1817).

Raja laevis Mitchill 1817[42]

Barndoor Skate, Sharp-nosed Skate

Figures 47, 48

Study Material. Thirty-one specimens, male and female, 7 3/8 to 52 inches long, from Nahant and Woods Hole, Massachusetts, Georges Bank, Nantucket Shoals, the continental shelf 70–80 miles southward from Marthas Vineyard, 50 miles east-southeast of Chesapeake Bay, and the offing of Charleston, South Carolina, in the collections of the Harvard Museum of Comparative Zoology and the U. S. National Museum;

41. It seems safe to assume that the two specimens for which depths of 1,043 and 1,255 fathoms are recorded were in fact picked up by the trawl on the bottom or close to it.

42. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 341, 342) substituted the name *stabuliforis* for this Skate to replace *laevis* on the ground that the latter had been preoccupied by Gronow (1763), Valmont (1768), and Duhamel (1782) for other species. But Valmont's and Gronow's names have been ruled out by the International Commission on Zoological Nomenclature (Opin. 89, Smithson. misc. Coll., 73 [3], 1925: 27), and Duhamel's names cannot be taken into account because, when binominal, they were so only incidentally.

also many specimens up to about five feet long examined by us in the field between Chesapeake Bay and eastern Maine.

Distinctive Characters. The midbelt of the disc of *R. laevis*, from the level of the axils of the pectorals to the vicinity of the spiracles, lacks large thorns, which sets it apart from all other Skates of the genus *Raja* of the western North Atlantic, except for *R. mollis* and *R. spinicauda*. And its thorny tail differentiates it from *mollis*. It is easily separable from *spinicauda* (at least from the time it is one-third grown) in that its tail is armed with three rows of thorns (only a single median row in *R. spinicauda*), and that the mucous pores on its lower surface are marked by conspicuous black dots and dashes (not so in *R. spinicauda* or in any other *Raja* of the western North Atlantic). Newly hatched specimens of *R. laevis*, on which the mucous pores are not yet pigmented (p. 222) and on which only one row of thorns has developed along the tail, may prove difficult to separate from *R. spinicauda* at a corresponding stage. The young of the latter have not been seen. *R. laevis* is so closely allied to the well known Gray Skate (*R. batis*) of the northeastern Atlantic, which also has the mucous pores of the lower surface marked by black dots and dashes, that future study may show that the two represent extremes of one varietal series. However, present indications are that the teeth average fewer in *R. laevis* (30–40) than in *R. batis* (44–55), those of females being relatively lower and more rounded; the tail may average a little longer in *R. laevis*; the lateral rows of thorns along the tail are more regular (often largely lacking in *R. batis*). On the other hand, the lower surface of the disc of some specimens is more generally prickly on *R. batis*.[43]

The only Skates known in the western Atlantic, other than *R. laevis*, which have pigmented mucous pores on the lower surface are *R. castelnaui* Ribeiro 1907[44] and some specimens of *R. agassizii* Müller and Henle 1841, both from Brazil;[45] *R. platana* Günther from Rio de Janeiro to the mouth of the Rio de La Plata; and *R. flavirostris* Philippi 1892 from the Patagonian-Falklands region and Straits of Magellan to Chile. The anterior contour of the disc is so much more obtuse in *R. castelnaui*, and the dorsal fins are so much farther removed from the tip of the tail in *R. agassizii*, that *R. laevis* is not likely to be confused with either of these species. *R. platana* and *R. flavirostris* resemble *R. laevis* closely in general form. But *R. flavirostris* is characterized by the presence of 2–3 strong thorns around each orbit and one large nuchal thorn, which are lacking on *R. laevis*. And in *R. platana* the median thorns on the tail (18 on specimen studied) are not only fewer and much larger than in *R. laevis* but are successively larger rearward; there are no side rows on the tail; the space between the eyes and also the mid-dorsal belt in the nuchal region (smooth in *R. laevis*) are close-set with small, low, rounded tubercles; and the caudal extension, posterior to the second dorsal fin, is considerably longer relatively than in *laevis*.

43. We have for comparison two large *R. batis* from Sweden.

44. Arch. Mus. nac. Rio de J., *14*, 1907: 177, pl. 15.

45. Some of the specimens of *R. agassizii* that we have examined have the mucous pores pigmented on the rostrum, around the mouth, and in the area between the gill openings, but others are immaculate below except for a sooty blotch under the tip of the snout.

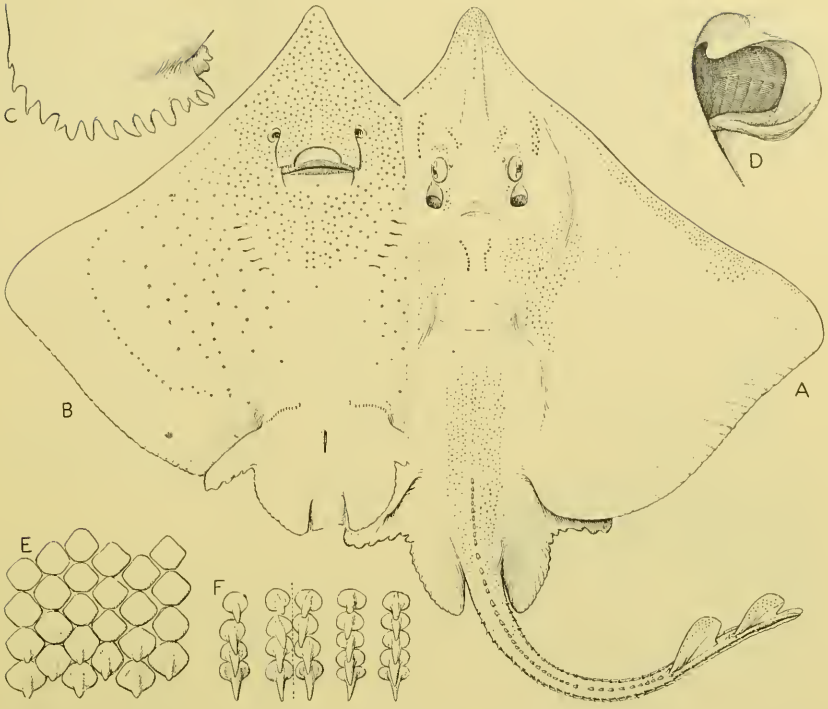


FIGURE 47. *Raja laevis*. *A* Dorsal view of female, 1,187 mm long, from off Massachusetts (Harv. Mus. Comp. Zool., No. 368). *B* Ventral view of another female, 676 mm long, from Nantucket Shoals (Harv. Mus. Comp. Zool., No. 36302), to show pigmented mucous pores. *C* Nasal curtain of same, about 2.6×. *D* Nostril of same, about 2.6×. *E* Upper teeth from center of jaw of female, 1,265 mm long, from Nantucket Shoals, about 3.5×. *F* Teeth from center of jaw of male, 1,320 mm long, from Nantucket Shoals (Harv. Mus. Comp. Zool., No. 36264), about 3.5×; symphysis marked by dotted line.

Among Skates of the Pacific Coast of North America, the closest counterparts to *R. laevis* are *R. rhina* Jordan and Gilbert 1880, also with pigmented mucous pores, and *R. binoculata* Girard 1854, both of which range from southern California to Alaska. However, the anterior margins of *R. rhina* are much more deeply concave than are those of *R. laevis*, and the snout of the former is narrower and considerably longer relatively (snout in front of mouth about 4 times as long as distance between orbits in *R. rhina*; only about 2.5–3 times in *R. laevis*), to mention only the more obvious differences. *R. binoculata* has two large orbital thorns and one large mid-dorsal thorn on the nuchal region when young but only one row of thorns (in addition to prickles) along the tail when adult; the mucous pores on its lower surface are not pigmented;

and in many cases the upper surface of each pectoral is marked with a large and conspicuous ocellar spot.

Description. Proportional dimensions in per cent of total length. Male, 1,064 mm, and female, 1,187 mm, from off Massachusetts (Harv. Mus. Comp. Zool., No. 368).

Disc: extreme breadth 74.3, 72.0; length 53,9, 51.8.
Snout length: in front of orbits 15.2, 15.7; in front of mouth 16.8, 15.6.
Orbits: horizontal diameter 3.8, 3.5; distance between 5.4, 5.5.
Spiracles: length 3.0, 2.5; distance between 7.2, 7.0.
Mouth: breadth 9.8, 9.2.
Nostrils: distance between inner ends 8.8, 8.0.
Gill openings: lengths, 1st 1.8, 2.0; 3rd 2.1, 2.1; 5th 1.5, 1.4; distance between inner ends, 1st 16.5, 17.0; 5th 10.4, 11.4.
First dorsal fin: vertical height 3.1, 3.4; length of base 5.7, 6.0.
Second dorsal fin: vertical height 2.4, 2.9; length of base 6.1, 4.9.
Pelvics: anterior margin 10.0, 10.1.
Distance: from tip of snout to center of cloaca 51.9, 50.8; from center of cloaca to 1st dorsal 31.7, 33.8; to tip of tail 48.1, 49.2; from rear end of 2nd dorsal base to tip of tail 3.8, 2.8.
Interspace between: 1st and 2nd dorsals 0.8, 1.8.

Disc about 1.4 times as broad as long, the maximum anterior angle in front of spiracles about 82–90°, a little more acute on newborn specimens than on larger; anterior margins weakly concave just posterior to tip of snout, weakly convex opposite eyes and spiracles (no more so in males than in females), weakly concave thence rearward; outer corners narrowly rounded, posterior corners more broadly so, posterior margins nearly straight forward but gently convex rearward. Axis of greatest breadth about 70 % of distance back from tip of snout toward axils of pectorals. Tail with lateral folds beginning posterior to axils of pelvics by a distance about $^4/_5$ as long as eye and extending nearly to tip; its length from center of cloaca to origin of first dorsal fin about 76 % as great as distance from center of cloaca to tip of snout in newly hatched specimens, about 70 % on half-grown ones, and about 66–68 % on large; total length of tail about 1.3 times as great as distance from center of cloaca to tip of snout at hatching, decreasing relatively to about as long as body sector, or a little shorter, at maturity.

Newly hatched specimens with 1–2 thorns in front of orbit and one behind, a row of about 14–17 along midline of tail from a little posterior to axils of pectorals to first dorsal fin, and one in interspace between first and second dorsals; otherwise smooth both above and below. Larger specimens with the pre- and post-ocular thorns replaced by patches of much smaller ones; also thorns in mid-dorsal row on tail increasing to 23–40 in both sexes, often irregularly spaced, the most anterior one a little behind axils of pectorals in some specimens but a little behind axils of pelvics in others; an additional continuous row of equally large thorns developing (irregularly at first) low

down along either side of tail from about opposite tips of pelvics about to level of second dorsal; a second thorn developing on some in interspace between first and second dorsals, the two members of the resultant pair usually standing side by side; small prickles also developing irregularly over restricted areas on snout, around and between eyes, along outer anterior margins of disc, on outer parts of dorsal fins, and along margin of caudal membrane. Maturing females becoming more or less prickly

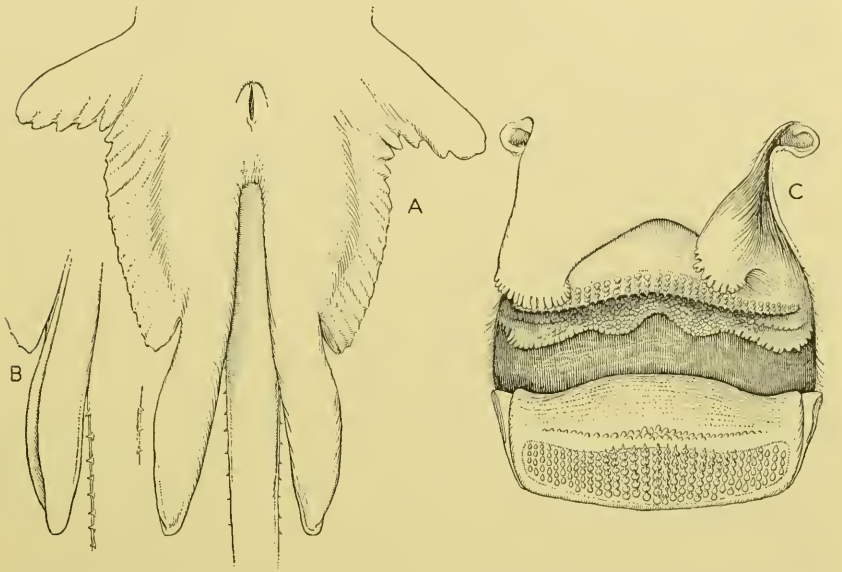


FIGURE 48. *Raja laevis*. *A* Ventral view of pelvics of mature male, 1,206 mm long, from off Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36691), about 0.23×. *B* Oblique view of clasper of same. *C* Opened mouth of same, with right-hand nasal curtain turned up to show nostril, transverse curtain on roof of mouth, and fleshy knobs on floor of mouth, about 0.45×.

over upper surface of tail, on posterior part of mid-dorsal belt of disc, on shoulders, and outward from eyes; also a few strong thorns, directed forward, developing on rostral ridge, with smaller thorns scattered along anterior margins of pectorals. Mature males smoother, the rostral ridge, region between orbits, and the central area of disc posterior to eyes with only a few sparsely scattered prickles. Tail also prickly apart from its thorns. Alar spines of sexually mature males in three rows. Lower surface glossy smooth on small specimens, likewise on large males except for a few prickles along margins of snout; but large females are rough with small spines and prickles along a narrow marginal belt from tip of snout to level of nostrils, and more or less prickly on spaces between first and third gill openings of each side and on anterior parts of pelvics.

Snout in front of orbits about 3–4 times as long as orbit in small specimens, 4–5 times in adults, its length in front of mouth 1.8–2.2 times as great as distance between exposed nostrils in young and old alike. Distance between orbits about as great as length of orbit at hatching, 1.4–1.7 times when full grown; orbits about 1.8 times as long as spiracles on young but about 1.3 times on adults. Distance between first gill openings 1.8–2.1 times as long as distance between exposed nostrils, between fifth gill openings 1.2–1.4 times; first gill openings 1.2–1.4 times as long as fifth and about 18–21 % as long as breadth of mouth. Nasal curtain deeply fringed, the individual lobes simple or bifid; expanded posterior (outer) margin of nostrils smooth. Upper jaw nearly straight, lower weakly arched in both sexes.

Teeth $\frac{30-40}{28-38}$, usually one or two more series in upper jaw than in lower, sometimes the reverse; those of females and of immature males close-set in quincunx, their bases nearly circular in outer series but quadrate with rounded corners in central series; the oldest (anterior) four or five rows worn smooth, the youngest (posterior) two or three rows with low conical median cusp; those of mature males more loosely spaced in transverse series, with conical cusp, considerably longest and sharpest in the younger rows.

First and second dorsals similar in size and shape. Interspace between dorsals 14–30 % as long as base of first dorsal, independent of size or sex. Caudal from rear end of base of second dorsal about 1.5 times as long as base of first dorsal on newly hatched specimens, about as long as base of first dorsal on half-grown specimens, but only about half as long on large. Pelvics noticeably small in area relative to disc, rather deeply concave, strongly scalloped around anterior side of the excavation but only weakly so rearward; anterior margin about $\frac{1}{2}$–$\frac{3}{4}$ as long as distance from its own origin to rear tip of pelvic; anterior lobe broad, including 5–6 radial cartilages besides the first stout one; posterior lobe strongly convex outwardly; rear tips abruptly rounded, extending rearward about $\frac{1}{4}$ the distance from axils of pelvics toward first dorsal. Claspers of sexually mature males conspicuously massive, reaching rearward about $\frac{3}{4}$ the distance from axils of pelvics toward first dorsal.

Anterior rays of pectorals extending about $\frac{2}{3}$ the distance from level of front of orbits toward tip of snout.

Color. On fresh specimens, the upper surface brownish, with many scattered small darker spots of various sizes, the largest usually about the size of eye, more numerous on some specimens than on others; usually a larger and irregularly elongate spot or blotch on inner part of each pectoral about level with outer corner. Mucous pores on nuchal region and anterior to eyes with black dots (Fig. 47). Lower surface white, frequently blotched irregularly with gray, especially on large individuals; specimens one-third grown and larger always with small black or dusky dots or short streaks marking the orifices of mucous pores, in continuous arcs around midbelts of pectorals, across midzone of disc, and on pelvic regions (Fig. 47 B); also scattered less regularly elsewhere. Very small ones may lack these black markings.[46]

46. The mucous pores on the smallest specimens we have seen (about 190 mm long) are only faintly visible after many years in alcohol, but they may have been more conspicuously marked when the specimens were fresh.

Size. The length at hatching probably averages about 180–190 mm.[47] It has been said that the Barndoor grows to a length as great as six feet; but the maximum that we find definitely reported is about five feet; the largest we have seen measured 58 inches. Specimens taken off southern New England weigh about $1\frac{1}{2}$–$1\frac{2}{3}$ pounds when 20 inches long, about 4–6 pounds at 28–30 inches, about 10–11 pounds at 36 inches, about 20–25 pounds at 45–46 inches, and 30–38 pounds at 50–56 inches.[48]

Developmental Stages. The yellowish or greenish brown egg cases, much larger than those of any other shoal-water Skate occupying the same geographic range, are 124–132 mm long by 68–72 mm broad, exclusive of the terminal horns, smooth-shelled, with slightly bulging sides, the horns short (only 13–19 mm long), stout basally but tapering to slender tips.[49] Fine filaments are attached to the margins of the case, but they are not united into a membrane. Normally the newly hatched Skates differ so little from their parents that they are easily identifiable.

Abnormalities. Two specimens, 19 and $20\frac{1}{2}$ inches long, in which the anterior parts of the pectorals continued separate from the sides of the head,[50] have been reported from Woods Hole.

Habits. The Barndoor Skate feeds chiefly on the larger crustacea, such as lobsters, crabs, spider crabs, and shrimps. But isopods have been found in the stomachs also, as have bivalves (*Yoldia*, and the razor clam *Ensella*), large gastropods (*Buccinum*, *Lunatia*), squid, and various worms. They are also more destructive to fishes than are other local Skates, their diet including spiny dogfish (*Squalus*), herring (*Clupea*), alewives (*Pomolobus*), menhaden (*Brevoortia*), sand launce (*Ammodytes*), cunners (*Tautogolabrus*), tautog (*Tautoga*), butterfish (*Poronotus*), sculpins (*Myoxocephalus*), whiting (*Merluccius*), hake (*Urophycis*), and various flatfishes. No doubt cod, haddock, etc., also suffer to some extent from them on the offshore fishing banks, for their European relative, *R. batis*, is a well known enemy of the cod. They bite readily on almost any bait.

The young are produced throughout the latitudinal range of the species. Females containing eggs have been taken off outer Nova Scotia as well as in Kennebecasis Bay, tributary to the New Brunswick shore of the Bay of Fundy, and recently hatched specimens have been captured on Nantucket Shoals and off Chesapeake Bay. It is probable that eggs are deposited from close to tide line down to the greatest depth at which this Skate ordinarily occurs.[51] Females containing fully formed capsules have been taken in December and January,[52] evidence that the eggs are laid in winter. However, it seems that the young are not hatched until late spring or early summer, for we

47. Specimens of about 190 mm, listed under Study Material, appear to have been newly hatched, to judge from the considerable lengths of their tails posterior to the second dorsal fin.
48. Information contributed by Daniel Merriman. Reported weights of 60 pounds (at a length of 3 ft.) and 200 pounds (Perley, Rep. Fish. Bay of Fundy, 1851: 154; Storer, Boston J. nat. Hist., 2, 1839: 545) were evidently much too high.
49. Account based on description and photograph by Vladykov (Nat. canad., 63, 1936: 216, 219) of egg cases taken from females off Nova Scotia and in Kennebecasis Bay, New Brunswick.
50. Radcliffe, Nat. Hist. N. Y., 28, 1928: 58; Gudger, Amer. Mus. Novit., 600, 1933: 1.
51. Eggs have been found in females caught in 15–25 fathoms and the empty cases have been picked up on the beach.
52. Vladykov, Nat. canad., 63, 1936: 216.

have a specimen, taken on Nantucket Shoals in mid-July, that is so small (193 mm long) that it could not have been set free long before its capture.

Barndoors are usually taken on sandy or gravelly bottom, but individuals that live in the deepest water are often on muddy ground. In the Gulf of Maine, for example, we have trawled them in the deep mud-floored troughs in company with *R. senta* and *R. radiata*.

The depth range for *R. laevis* covers the whole breadth of the continental shelf, from tide-mark down to 235 fathoms;[53] the 5-fathom and the 70–80-fathom contours approximately enclose the zone of greatest abundance and of most regular occurrence.

It has been reported off northern Nova Scotia and on the southwestern part of the Newfoundland Banks in water as cold as 1.2 and 2.2° C (about 34 and 36° F). The facts that many more are taken in autumn than in summer in shoal water along southern New England and that they are reported as not entering Sandy Hook Bay near New York City until the water has cooled to about 17° C (63° F), suggest that this is near the upper limit of the optimum range of the species. However, the individuals that live closest inshore (i. e., shoalest) along southern New England and southward may be in water as warm as 18–20° C (about 64–68° F) in summer, if not warmer. Especially interesting in this connection is the report of small *R. laevis* being taken in 18 fathoms off Cape Lookout, North Carolina in mid-August[54] when the bottom temperature there was probably not less than 22–24° C (72–76° F).

R. laevis occurs in salinities that range from about 35 ‰ along the continental edge to 31–31.5 ‰ inshore along the open coast and to as low as 21–24 ‰ within the mouth of Chesapeake Bay. One specimen has even been reported from so far up the Delaware River (above Philadelphia) as to suggest that *R. laevis* may occasionally run up into water that is only slightly saline or even fresh.

The fact that *R. laevis* is taken much more regularly and in larger numbers close inshore along southern New England, New York, and New Jersey in autumn and spring than in summer suggests that the inshore fringe of the population tends to move out into slightly deeper water during the warmest season and to move shoreward again as the water cools with the onset of autumn. It is likely also that such individuals as come into water less than a fathom or so in depth during autumn tend to withdraw again during the winter as the water chills. But there is no reason to suppose that these thermal migrations involve such of the stock as live deeper than 5–10 fathoms (including the great majority of the population), for Barndoors are taken regularly on the offshore fishing banks in winter as well as summer.[55]

53. The records of greatest depth are 120 fathoms on the southwest slope of the Grand Banks of Newfoundland; 235 fathoms along the continental edge off Nantucket, Massachusetts; 105 fathoms in the western side of the Gulf of Maine; 110 fathoms in the central basin of the Gulf; and 159 fathoms off Charleston, South Carolina.

54. Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 273.

55. It is taken throughout the year in the vicinity of Nantucket Lightship where it is especially plentiful in winter in depths of about 30–50 fathoms and in summer in about 20 fathoms (reported by Captains Jared Vincent and H. W. Klimm, catches from 1945–1950). And we saw many trawled in midwinter south of Rhode Island in 47–67 fathoms (by the EUGENE H., January 27 to February 3, 1950), as well as along the southern New England Coast in May (by the ALBATROSS III).

Nor is it likely that any north–south migration takes place with the seasons, *R. laevis* having been taken off North Carolina both in August and in December–January.

Relation to Man. This species (with a few *R. ocellata*) provides the greater part of the small landings of Skates along the Atlantic Coast of the United States that are used for food. The fleshy basal parts of the pectorals, known as "skate saddles," are the only portions marketed.

Numerical Abundance. The average catch per hour, made by one trawler with an 80-foot trawl, between August 1943 and October 1944 at the eastern end of Long Island Sound was 25–73 pounds, or about two specimens per hour if the average weight were 12–15 pounds.[56] This corresponds to a population of about 120 specimens per square (sea) mile, assuming that the strip swept by the trawl was 50 feet wide, that the distance covered per hour was two miles, and that the trawl picked up every Skate that lay in its path, which certainly was not the case. Also, 37 hauls made with an otter trawl on Georges Bank during September 1929 yielded 42 *R. laevis* from a total of 495 Skates of all kinds. Off southern New England 44 midwinter hauls in 47–67 fathoms and 63 hauls in May at 22–235 fathoms yielded 441 *R. laevis* from a total of 748 Skates of all kinds. And as many as three dozen have been taken from one of the fish traps in Narragansett Bay in one lift, according to an old report.

Range. Atlantic shelf of North America, from the Grand Banks of Newfoundland and southern side of the Gulf of St. Lawrence to North Carolina; also doubtfully reported from Florida.

Details of Occurrence. The most northerly records of *R. laevis* are for the southwestern parts of the Newfoundland Banks (reported from three stations) and from the southern side of the Gulf of St. Lawrence (Cape Breton and Magdalen Islands), where large ones have been described as fairly common. It occurs all along the outer coast of Nova Scotia, both inshore and on the offshore fishing banks; on both sides of the Bay of Fundy, including the larger tributary bays such as St. Mary, Kennebecasis, and Passamaquoddy; along the coast of Maine; in Massachusetts Bay where we have seen many; also on Georges Bank and on Nantucket Shoals where it is taken in some numbers by trawlers. In fact, any very large Skate reported from the Gulf of Maine or from the offshore fishing grounds that front the latter is almost certain to have been a Barndoor. It is present throughout the year on the continental shelf off southern New England and, in season, it is equally universal all along that coast, off New York, New Jersey and Maryland, and doubtless off the northern coast of Virginia,[57] for it is frequently taken in pound nets in the lower part of Chesapeake Bay. There is a record of it between Cape Charles and Cape Hatteras;[58] odd individuals have been taken near Cape Lookout, North Carolina, and our Study Material includes a small specimen

56. Merriman and Warfel, 9th N. Amer. Wildl. Conf., 1944: 234.
57. Reported thence from two localities only.
58. One specimen, trawled on February 11, 1930 by the U. S. Fisheries steamer ALBATROSS II off Bodie Island, North Carolina, in 16 fathoms.

from the offing of Charleston, South Carolina. But it is questionable whether it ranges regularly any farther south than this, although it has been credited to Florida.[59]

Synonyms and References:

Raja[60] *laevis* Mitchill, Amer. Mon. Mag., *2*, 1817: 327 (descr., New York); DeKay, Zool. N. Y., 4, 1842: 370 (descr., New York); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 259 (in synopsis); Perley, Rep. Fish. Bay of Fundy, 1851: 154; also Cat. Fish. N. Brunsw. and Nova Scotia, 1854: 38 (food, size, Bay of Fundy); Wyman, Proc. Boston Soc. nat. Hist., *6*, 1859: 44 (electric organs); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed, Atlant. Coast N. Amer.); Knight, Descr. Cat. Fish. Nova Scotia, 1866: 8 (descr., Nova Scotia); Storer, Mem. Amer. Acad. Arts Sci., N. S. *9*, 1867: 242; also Fishes Mass., 1867: 266 (descr. in part but not ill., pl. 39, fig. 2, which is *R. radiata*); Abbott, in Cook, Geol. N. J., 1868: 829 (util., Delaware R.); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 455 (footnote); Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: 53 (nos., size, south. Mass.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (listed, Nova Scotia to Florida); Verrill and Smith, Rep. U. S. Comm. Fish. (1871–1872), 1873: 521 (food, Woods Hole); Garman, Proc. Boston Soc. nat. Hist., *17*, 1874: 180 (descr., color, size, Massachusetts Bay); Uhler and Lugger, Rep. Comm. Fish. Md., ed. 1, 1876: 189; ed. 2, 1876: 160 (Maryland, Chesapeake Bay); Yarrow, Proc. Acad. nat. Sci. Philad., 29, 1877: 217 (listed, near Beaufort, N. Carolina); Goode and Bean, Bull. Essex Inst. Salem, *11*, 1879: 28 (N. Massachusetts); Jones, List Fish. Nova Scotia, 1879: 11 (Bay of Fundy); Verrill, Amer. J. Sci., *22* (3), 1881: 297 (43–202 fath., off Gay Head); Jones, Proc. N. S. Inst. Sci., 5 (1), 1882: append. 97 (Bay of Fundy); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 42 (descr., Virginia); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Bean, Rep. U. S. Comm. Fish. (1881), 1884: 343 (listed, Woods Hole); Goode, Fish. Fish. Industr. U. S., 1, 1884: 667 (util.); Rathbun, Proc. U. S. nat. Mus., *7*, 1884: 486 (copepod parasites, depth, off Woods Hole); Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 90, pls. 27–29 (mucous canal syst.); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed, N. Atlant. states, U. S.); Bean, Bull. U. S. Fish Comm., *7*, 1889: 151 (New Jersey); Proc. U. S. nat. Mus., *14*, 1891: 94 (Chesapeake Bay); Moore, Bull. U. S. Fish Comm., *12*, 1894: 358 (New Jersey); Smith, Bull. U. S. Fish Comm., *12*, 1894: 368 (nos., util., weight, New Jersey); Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 28; *31*, 1895: pl. 9, fig. 29; also Spec. Bull. U. S. nat. Mus., 1895; and Mem. Harv. Mus. comp. Zool., *22*, 1896: 28, pl. 9, fig. 29 (ill., depth, continental slope off New England); Smith, Bull. U. S. Fish Comm., *14*, 1895: 345 (common names, mid-Atlant. U. S.); Cox, Bull. nat. Hist. Soc. New Brunsw., 13, 1896: 63 (listed, N. Brunswick); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 71 (descr., New England to Florida); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, New England to Florida); Bean, Bull. Amer. Mus. nat. Hist., *9*, 1897: 423, 441 (cestode parasites, Woods Hole); Proc. U. S. nat. Mus., *20*, 1898: 507, 522 (trematode parasites); Smith, Bull. U. S. Fish Comm., *17*, 1898: 89 (season, Woods Hole); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (depth, range); Bean, 6th Rep. For. Comm. N. Y., 1900: 383 (New York and C. Cod); Linton, Bull. U. S. Fish Comm., *19*, 1901: 431 (parasites, food, depth, off Woods Hole); Bean, Bull. N. Y. St. Mus., 60, Zool. *9*, 1903: 50 (descr., season, near New York and Woods Hole); Sharp and Fowler, Proc. Acad. nat. Sci. Philad., *56*, 1904: 506 (listed, Nantucket); Linton, Bull. U. S. Bur. Fish., *24*, 1905: 346 (food, cestode parasites, C. Lookout, N. Carolina); Wilson, Proc. U. S. nat. Mus., *28*, 1905: 573, 582 (copepod parasites); Fowler, Rep. N. J. Mus. (1905), 1906: 73, pl. 3 (descr., ill., New Jersey); Tracy, 36th Rep. R. I. Comm. inl. Fish., 1906: 47 (season, food, size, Rhode Island); Fowler, Rep. N. J. Mus. (1906), 1907: 259 (season, New Jersey); Smith, N. C. geol. econ. Surv., *2*, 1907: 41 (food, near C. Lookout, N. Carolina); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 13 (New England locals.); Fowler, Proc. Acad. nat. sci. Philad., *61*, 1909: 407 (New Jersey); Rep. N. J. Mus. (1908), 1909: 353 (Delaware R., by ref. to Abbott, 1868); Tracy, 40th Rep. R. I. Comm. inl. Fish., 1910: 62 (Rhode Island); Cornish, Contr. Canad. Biol. (1906–1910), 1912: 79 (nos., Prince Edward I.); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 98 (season, N. Carolina); Engelhardt, Abh.

59. Egg cases with embryos, washed ashore near Charlotte Harbor many years ago, were doubtfully referred to this species (Henshall, Bull. U. S. Fish Comm., 2, 1891:372).

60. Sometimes spelled *Raia*.

bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Halkett, Check List Fish. Canad., 1913: 42 (listed, Maritime Provinces to Florida); Nichols, Abstr. Linn. Soc. N. Y., 20–23, 1913: 91 (nos., season, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31*, 1913: 738 (food, parasites, nos., season, near Woods Hole); Fowler, Copeia, 13, 1914: [2] (listed, New Jersey); Proc. Acad. nat. Sci. Philad., *66*, 1914: 353 (season, New Jersey); Coles, Proc. biol. Soc. Wash., *28*, 1915: 92 (season, off C. Lookout, N. Carolina); Wilson, Proc. U. S. nat. Mus., *47*, 1915: 641 (copepod parasites, Maine); Fowler, Copeia, 31, 1916: 41 (depth, New Jersey); Latham, Copeia, 41, 1917: 18 (season, size, Long Island, New York); Fowler, Proc. Acad. nat. Sci. Philad., *71*, 1920: 293 (New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 145 (New Jersey); Cox, Contr. Canad. Biol. (1918–1920), 1921: 109 (S. side Gulf St. Lawrence); Townsend, N. Y. zool. Soc., 25th Annu. Rep. (1920), 1921: 126 (listed, New York Bay); Scott, Contr. Canad. Biol., N. S. *2* (8), 1924: 131 (pathol. thyroid gland); Trans. roy. Soc. Canad., (3) *20* Sect. 5 (2), 1926: 229 (histol., physiol., thyroid gland); Burwash, Contr. Canad. Biol., *4*, 1929: 117, 118 (iodine content, thyroid gland); Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1929: 608 (weight, season, New Jersey); Jordan, Manual Vert. Anim. NE U. S., 1929: 17 (diagn., size, name); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 31 (descr., nos., Atlant. Coast Maryland, and Chesapeake Bay); Bere, Contr. Canad. Biol., *5*, 1930: 423, 426 (copepod parasites, Passamaquoddy Bay); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (listed, NE coast N. Amer.); Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51 (ill., depth, Nova Scotia); Vladykov, Nat. canad., *63*, 1936: 216 (descr., photo egg cases, breeding season, depth, temp. off N. Scotia and Kennebecasis Bay, New Brunswick); Breder and Nichols, Copeia, 1937: 182 (egg cases); Fowler, Proc. Acad. nat. Sci. Philad., *89*, 1937: 304 (New Jsersey); Merriman and Warfel, Bull. Bingham oceanogr. Coll., *11* (4), 1948: 134 (listed, off Connecticut).

Raia chantenay Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 106, pl. 5 (descr., ill., no local.); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 512 (after Lesueur, 1824).

Raia batis Storer, Boston J. nat. Hist., *2*, 1839: 545 (descr., size, Mass.); Rep. Fish. Rept. Birds Mass., 1839: 193 (same as preceding); Linsley, Amer. J. Sci., *47*, 1844: 77 (Connecticut).

Barn Door Skate, Wilson, Proc. U. S. nat. Mus., *31*, 1907: 711 (copepod parasites); Bull. U. S. nat. Mus., 158, 1932: 399, 403, 419 (copepod parasites, Woods Hole).

Raia[61] *stabuliforis* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 341, pl. 22, fig. 2, pl. 44, figs. 4–6 (descr., ills., name *R. laevis* considered preoccupied); Kendall, Proc. Portland Soc. nat. Hist., *3* (1), 1914: 13 (Maine locals.); Radcliffe, Trans. Amer. Fisher. Soc., *44*, 1914: 38 (teeth); Bull. U. S. Bur. Fish., *34*, 1916: 272, pl. 45 (descr., photos teeth, C. Lookout, N. Carolina); Jordan, Copeia, 49, 1917: 88 (*R. stabuliforis* replaces *R. laevis*, preoccupied); Huntsman, Contr. Canad. Biol. (1921), 1922: 57 (Passamaquoddy Bay and Bay of Fundy); Breder, Copeia, 127, 1924: 28 (season, temp., near New York); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 9, 11, 20, 24, 28, 66 (cestode parasites); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 66 (descr., ill., habits, Gulf of Maine); Manter, Illinois biol. Monogr., *10* (2), 1926: 8, 9, 16, 43 (parasites); Nichols and Breder, Zoologica N. Y., *9*, 1927: 25 (ill., habits, near New York and south. New England); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 59 (descr., Chesapeake Bay); Radcliffe, Nat. Hist. N. Y., *28*, 1928: 58 (abnormality, Woods Hole); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 32 (genl.); Marshall, Contr. Canad. Biol., 7 (1–7), 1931: 19 (heart physiol.); Anon., Rep. Newfoundland Fish. Res. Comm., *1* (4), 1932: 107 (depth, SW. part Grand Banks); Gudger, J. Elisha Mitchell sci. Soc., *49*, 1933: 63 (abnormal dentition); Amer. Mus. Novit., 600, 1933: 1 (ill., abnormality, Woods Hole); Anon., Rep. Newfoundland Fish. Res. Comm., *2* (1), 1933: 125 (Grand Banks, Banquereau Bank off Cape Breton); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 35 (descr., ill., depth, Gulf of St. Lawrence, Grand Banks to Florida); Anon., Rep. Newfoundland Fish. Res. Comm., *2* (2), 1934: 115 (Banquereau and C. Breton, Nova Scotia); Roth, Arch. int. Pharmacodyn., *49* (3), 1935: 355 (cardiac regulative nerves; not seen); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 325 (nos., size, depth, Georges Bank and Nantucket Shoals); Smith, H. W., Biol. Rev. (Cambridge), *11*, 1936: 67 (blood serum, urine); Norman and Fraser, Giant Fishes, 1937: 68 (Atlant. Coast N. Amer.); Breder, Bull. N. Y. zool. Soc., *41*, 1938: 28 (listed, New York Harbor); Bigelow and Schroeder, Biol. Bull. Woods Hole, 76, 1939: 309 (Gulf of Maine); Merriman and Warfel, Trans. 9th N. Amer. Wildl. Conf., 1944: 234 (mean catch per hour, Long Island Sound).

61. Sometimes spelled *Raja*.

Probable Synonym:

Raia granulata Goode and Bean, Bull. Essex Inst., *11*, 1879: 28; Smithson. Contr. Knowl., *31*, 1895: pl. 9, fig. 30; Mem. Mus. comp. Zool. Harv., *22*, 1896: pl. 9, fig. 30 (see discussion, p. 216).

Doubtful Reference:

Raia laevis (?) Henshall, Bull. U. S. Fish Comm., *9*, 1891: 372 (embryos, doubtfully ident., Stump Pass, SW. Florida); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (SW. Florida, by ref. to Henshall, 1891).

Not *Raja laevis* Gronovius, Zoophyl., *1*, 1763: 37, no. 158, pl. 9, fig. 3 (equals *Narcine brasiliensis* Olfers 1831; see p. 112, footnote 129); Valmont, Dict. Hist. Nat., *3*, 1768: 706 (equals *Raja oxyrincha* Linnaeus 1758).

Not *Raia laevis alba* Duhamel, Traité Pêches, (2) *3* Sect. 9, 1782: 284, pl. 11 (equals *R. batis* Linnaeus 1758).

Not *Raia laevis major* Duhamel, Traité Pêches, (2) *3* Sect. 9, 1782: 285 (equals *R. marginata* Lacépède 1803).

Not *Raia laevis* Seal, Aquarium, *2* (10), 1914: 105 (probably not *R. laevis*, because female only 15 in. wide with eggs; perhaps *R. ocellata*, see p. 251).

Not *Raia stabuliforis* von Bonde and Swart, Fish. Mar. biol. Surv. S. Afr., Rep. 3 (1922), Spec. Rep. 5, 1924: 12 (a South African form subsequently ref. to the synonomy of *R. marginata* Lacépède 1803 by Barnard [Ann. S. Afr. Mus., *21* (1), 1925: 65] and to that of the South African representative of *R. batis* Linnaeus 1758 by Norman ['Discovery' Rep., *12*, 1935: 39]).

Not *Raia stabuliforis* Marini, Physis B. Aires, *9*, 1928: 138 (equals *R. flavirostris* Philippi 1892).

Raja lentiginosa Bigelow and Schroeder 1951

Figure 48α

Study Material. Male, 402 mm in total length, and female, 302 mm, from Lat. 22°32′ N, Long. 88°47′ W, 29 fathoms, Oregon St. 222; male, 323 mm, from Lat. 28°10′ N, Long. 85°00′ W, 85 fathoms, Oregon St. 256; a male and two females, 151–234 mm, from Lat. 28°41′ N, Long. 86°03′ W, 165 fathoms, Oregon St. 257; a male, 395 mm, from Lat. 28°49′ N, Long. 85°45′ W, 112 fathoms, Oregon St. 278; a male, 415 mm, from Lat. 29°11′ N, Long. 86°52′ W, 305 fathoms, Oregon St. 279; and a female, 375 mm, from Lat. 29°27′ N, Long. 87°26′ W, 104 fathoms, Oregon St. 318; and a male and two females, 330–402 mm, from Lat. 27°50′ N, Long. 91°11′ W, 205 fathoms, Oregon St. 500; all in the collections of the U. S. National Museum and the Harvard Museum of Comparative Zoology.

Distinctive Characters. Raja lentiginosa closely resembles *R. garmani*, but it may be distinguished from the latter by the color pattern of its upper surface, which is densely freckled with small dark, light brown and whitish spots (sparse in *garmani* and grouped mostly in a distinct rosette pattern).

Description. Proportional dimensions in per cent of total length. Male, 402 mm (U. S. Nat. Mus., type, No. 153552), and female, 302 mm (Harv. Mus. Comp. Zool., No. 37188), from Lat. 22°32′ N, Long. 88°47′ W, 29 fathoms.

Disc: extreme breadth 60.0, 52.3; length 46.5, 44.3.

Snout length: in front of orbits 9.2, 9.7; in front of mouth 11.2, 10.3.

Orbits: horizontal diameter 4.2, 4.7; distance between 2.9, 2.8.

Spiracles: length 2.1, 2.5; distance between 6.2, 6.3.

Mouth: breadth 6.5, 7.2.

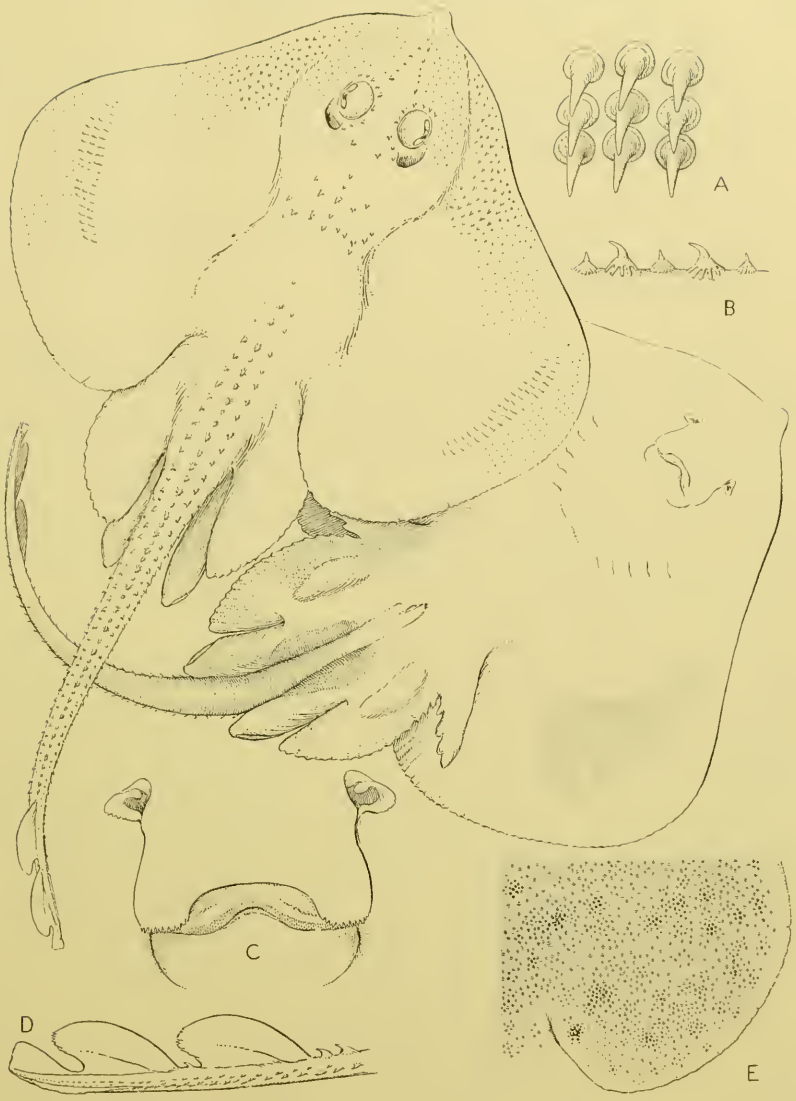


FIGURE 48α. *Raja lentiginosa*, male, 402 mm long, from Campêche Bank, Lat. 22°32′ N, Long. 88°47′ W (U. S. Nat. Mus., No. 153552, type). *A* Upper teeth, about 10×. *B* Thorns in midrow on tail, about 2×. *C* Mouth and nostrils, about 1.5×. *D* Posterior part of tail, about 1×. *E* Section of upper surface to show color pattern.

Nostrils: distance between inner ends 6.0, 6.2.
Gill openings: length, 1st 2.0, 1.5; 3rd 1.9, 1.8; 5th 1.2, 1.5; distance between inner ends, 1st 13.9, 14.3; 5th 7.0, 7.8.
First dorsal fin: vertical height 3.0, 2.0; length of base 5.6, 5.3.
Second dorsal fin: vertical height 3.0, 2.0; length of base 5.5, 4.3.
Pelvics: anterior margin 12.2, 11.0.
Distance: from tip of snout to center of cloaca 39.2, 41.3; from center of cloaca to 1st dorsal 45.3, 44.0; to tip of tail 60.8, 58.7; from rear end of 2nd dorsal base to tip of caudal 2.9, 2.3.
Interspace between: 1st and 2nd dorsals 1.2, 2.0.

Disc about 1.2–1.3 times as broad as long, the maximum angle in front of spiracles about 120°; anterior margins weakly convex from just posterior to tip of snout to opposite orbits, thence gently concave between spiracles and outer corners, which are broadly rounded; posterior margins and corners and inner margins all rounded. Axis of greatest breadth about 68 % of distance back from tip of snout to axils of pectorals. Tail with lateral fold low down on each side beginning abruptly posterior to axils of pelvics by a distance about equal to space between spiracles and continuing almost to extreme tip; width of fold about the same throughout its length; length of tail from center of cloaca to origin of first dorsal fin 1.1–1.2 times as great as, its length to tip 1.4–1.5 times as great as, distance from center of cloaca to tip of snout.

Four to six prominent thorns along anterior edge of orbit, none or one opposite its inner central margin, and two to five along its posterior margin, the last opposite spiracle; an additional thorn inward from this last one; a row of thorns over margins of rostral process; prickles and small thorns present over anterior third of disc in advance of nuchal region, extending along outer margin rearward about to axils of pectorals; a triangular patch of about 15–17 thorns on shoulder region, 4 or 5 of which extend along median line from nuchal to scapular region; a naked area behind these for a distance about equal to length of distance between spiracles on males (not on females); band of 3–5 rows of thorns along median zone of back and tail from nuchal region to first dorsal, the thorns rather regular on some specimens but irregular on others, the lowermost row reaching nearly to tip of tail, the median row consisting of about 45–53 thorns in most cases, large and small alternating on males but all of about equal size on females; most of the thorns on tail with sharp points, directed rearward; 1–4 prominent thorns in space between dorsals; prickles on dorsal fins and caudal; skin over eye naked. Males with a band of alar spines in one to three rows on outer part of each pectoral, the longest row with 19 spines. Female of 302 mm with small thorns on posterior part of pectorals and a few on pelvics. Lower surface naked except for a small median patch of spines at extreme tip of snout, lacking on our specimens of 232 mm and smaller.

Snout in front of orbits 2.0–2.2 times as long as orbit, its length in front of mouth about 1.7–1.8 times as great as distance between exposed nostrils. Orbit about twice

as long as spiracle; distance between orbits about 0.6–0.7 as great as length of orbits. Distance between first gill openings 2.3 times as great as distance between exposed nostrils; between fifth openings 1.2–1.3 times; first gill openings 1.0[62]–1.6 times as long as fifth and 0.2–0.3 as long as breadth of mouth. Nasal curtain fringed; expanded posterior (outer) margins of nostrils fringed. Upper and lower jaws rather strongly arched centrally.

Teeth $\frac{46-55}{46-54}$, close-set; those in nearly mature males mostly in straight series (not in quincunx), with small base, circular or oval, those in median sector of mouth with slender sharp cusp pointing toward symphysis or inward toward throat, those in outer sector with triangular cusp pointing toward corner of mouth, the one series of teeth at symphysis in upper jaw pointing straight downward; those in female in quincunx, ovate, with low triangular cusp not pointing inward or outward; no symphysis tooth.

First and second dorsals similar in size and shape. Interspace between dorsals 0.22–0.38 as long as base of first dorsal. Caudal membrane from rear end of base of second dorsal about half as long as base of first dorsal. Pelvics deeply concave, strongly scalloped along anterior side of excavation but only weakly so rearward; anterior margin 0.52–0.55 as long as distance from its own origin to rear tip of pelvic; anterior lobe slender, including four radial cartilages besides the first stout one; posterior lobe moderately convex along its forward half, thence nearly straight to its narrowly rounded tip, extending a little more than $^1/_5$ of the distance from axil of pelvics toward first dorsal; inner margin straight. Claspers on 402-mm male reaching beyond tips of pelvics by a distance about equal to diameter of orbit.

Rostral cartilage firm and extending nearly to tip of snout. Anterior pectoral rays reaching about $^7/_{10}$ of the distance from front of orbits toward tip of snout.

Color. Upper surface sprinkled everywhere with small light to dark brownish and whitish spots, including the tail, pelvics and claspers; many groups of about 30–50 dark spots scattered everywhere, the most prominent marking being the group of spots at axil of pectoral; some of spots on tail grouped in form of about five or six prominent bars; light and dark spots also present on anterior part of each dorsal fin and on caudal. Whitish below; a group of grayish blotches, mostly fused, on each pectoral, and an elongate blotch of the ground color of upper surface along inner part of claspers, anteriorly, on nearly mature males. Younger specimens of both sexes without these blotches.

Size. On a 232-mm male the claspers extend a little beyond the tips of the pelvics, while on a 285-mm specimen of *R. garmani* they fail to reach the tips of the pelvics by a distance as great as the diameter of the orbit. This suggests that *lentiginosa* matures at a length a little below 400 mm (see *garmani*, p. 204).

Occurrence. This newly discovered species is apparently widespread in the Gulf of Mexico, for it has been trawled in depths of 29, 85, 104, 112, 165, 205 and 305 fathoms and in bottom temperatures ranging from 48.5° F (305 fath.) to 73.4° F

62. It is exceptional to find a *Raja* with the fifth pair of gill openings as long as the first pair, but such was the case on the female 302 mm long.

(29 fath.). It is known from the northern part of the Gulf in the offings of Pensacola and Cape San Blas, Florida and in the southern part on Campeche Bank.

Reference:
Raja lentiginosa Bigelow and Schroeder, J. Wash. Acad. Sci., *41* (12), 1951: 383 (descr., ill., Gulf of Mexico).

Raja lintea Fries 1838

Figures 49, 50

Study Material. Female, 1,050 mm long, and adult male, 970 mm, from Iceland (British Museum [Natural History]).

Distinctive Characters. R. lintea falls in the group in which there is a single row of large thorns along the median belt of the disc and in which the thorns of the median row along the tail are much larger than those of any other rows. Among Skates of the western North Atlantic, it is closest to *R. hyperborea* and *R. jenseni* in general appearance and in the arrangement of thorns. But it is sharply marked off from both of these by a considerably larger number (47–51) of thorns in the mid-dorsal row from nuchal region to first dorsal fin and by its longer and narrower snout, the distance from its tip to the level of the front of the orbits being considerably greater than the distance between the outer edges of the spiracles (shorter than that in *R. hyperborea* and in *R. jenseni*). *R. lintea* does not bear a close resemblance to any Skate so far described either from boreal latitudes in the western South Atlantic or from the Bering Sea–Northeast Siberian region of the Pacific.

Description. Proportional dimensions in per cent of total length. Male, 970 mm, and female 1,050 mm, from Iceland (specimens from British Museum [Natural History]).

Disc: extreme breadth 65.7, 64.0; length 54.3, 54.3.
Snout length: in front of orbits 14.8, 16.5; in front of mouth 16.3, 18.2.
Orbits: horizontal diameter 3.6, 4.0; distance between 5.1, 4.1.
Spiracles: length 2.6, 2.6; distance between 8.0, 8.1.
Mouth: breadth 10.4, 10.0.
Nostrils: distance between inner ends 8.6, 9.3.
Gill openings: lengths, 1st 1.3, 1.2; 3rd 1.4, 1.5; 5th 0.9, 0.9; distance between inner ends, 1st 15.5, 15.3; 5th 9.7, 9.7.
First dorsal fin: vertical height 3.3, 2.6; length of base 4.9, –.
Second dorsal fin: vertical height 2.4, 2.4; length of base 4.6, 4.3.
Pelvics: anterior margin 9.0, 9.5.
Distance: from tip of snout to center of cloaca 51.0, 53.2; from center of cloaca to 1st dorsal 38.8, 37.2; to tip of tail 49.0, 46.8; from rear end of 2nd dorsal base to tip of caudal 0.5, 0.4.
Interspace between: 1st and 2nd dorsals 2.0, 0.0.

Disc about 1.2 times as broad as long, the maximum anterior angle in front of spiracles about 85–90°; tip of snout rounded, rather markedly protruding in male but

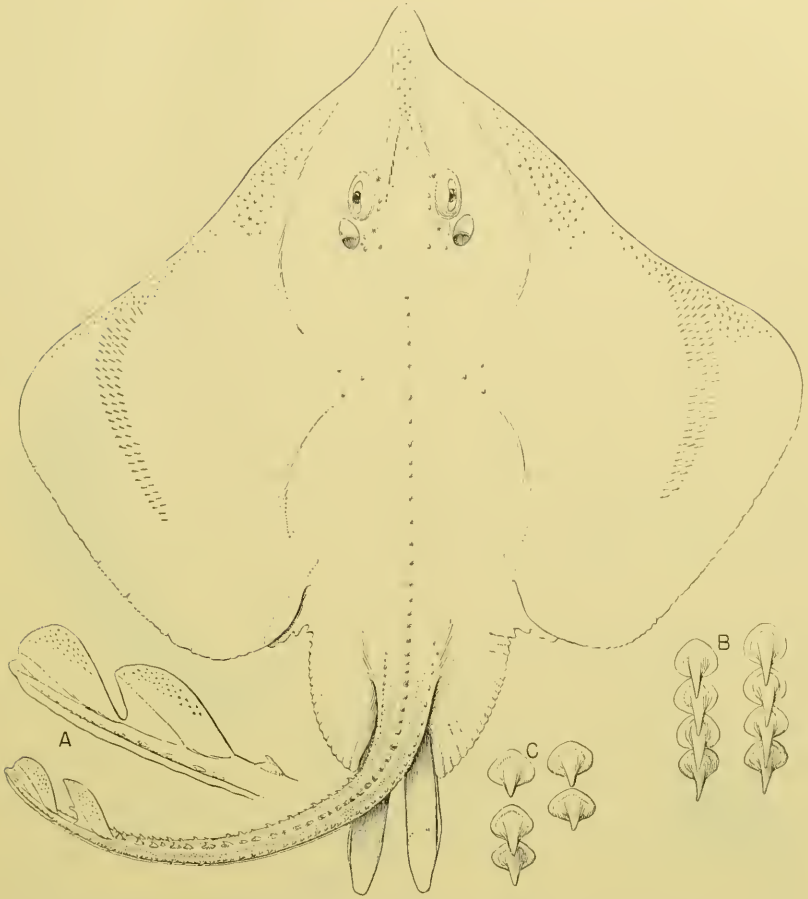


FIGURE 49. *Raja lintea*, male, 970 mm long, from Iceland (British Museum [Natural History]). *A* Side view of posterior part of tail of same, about 0.5×. *B* Upper teeth of same from near center of jaw, about 5.5×. *C* Upper teeth of female, 1,050 mm (British Museum [Natural History]).

less so in female; anterior margins of pectorals in adult male deeply concave just posterior to snout and again at level of spiracles, but only weakly incurved posterior to level of spiracles in adult females; otherwise nearly straight; outer and posterior corners broadly rounded, the latter continuously so to axils of pectorals; posterior margins nearly straight or weakly convex. Axis of greatest breadth about 70 % of distance rearward from tip of snout toward level of axils of pectorals. Tail with narrow lateral folds along posterior

FIGURE 50. *Raja lintea*. *A* Lower side of male pictured in Fig. 49. *B* Margin of nasal curtain, about 2.1 ×. *C* Nostril of same, about 2.5 ×. *D* Outline of snout of female of about the same size (British Museum [Natural History]). *E* Ventral view of pelvics of same, about 0.2 ×.

half to third; its length from center of cloaca to first dorsal about 0.7 as great, to tip of tail about 0.9 as great, as distance from center of cloaca to snout on large specimens.

Upper surface of half-grown and larger specimens with a single median row of

large thorns; about four anterior to pectoral girdle, about 11–12 from pectoral girdle to level of axils of pectorals, and about 35–36 along tail to first dorsal (no thorn, however, between first and second dorsals when these are separated); each side of tail with 1–3 irregular rows of smaller thorns anteriorly, one row posteriorly, extending to level of origin of second dorsal; disc also with two large thorns (sometimes worn flat) on each shoulder in small specimens, three in larger, these increasing in relative size with growth; 3–5 smaller thorns inward from posterior part of spiracle, 1–2 larger ones close in front of orbit, one large one just behind orbit and 2–3 around its inner edge; rostral ridge with an irregular band of small thorns, but tip of snout bare; outer anterior margins of pectorals more or less prickly along a narrow band; regions opposite eyes (sparsely prickly on partly-grown specimens) with a patch of thorns, large to small, in adults of both sexes; pelvics smooth, but upper portions of dorsals prickly. Alar spines of mature males in 2–3 rows. Lower surface smooth in young, in mature males and in some adult females, but other mature females are described as having a patch of 2–3 medium-sized thorns a little back from tip of snout.[63]

Snout anterior to orbits about 2.8–4.0 times as long as distance between orbits, its length in front of mouth about two times as great as distance between exposed nostrils. Orbit about 80 % as long as distance between orbits and about 1.5 times as long as spiracle. Distance between first gill openings 1.6–1.8 times, between fifth gill openings 1.0–1.1 times, as long as distance between exposed nostrils; first gill openings 1.3–1.4 times as long as fifth and about 12 % as long as breadth of mouth. Nasal curtain conspicuously fringed, but expanded posterior (outer) margin of nostrils smooth. Mouth only weakly arched centrally, even in adult male.

Teeth $\frac{50}{48}$ (in two specimens), rather widely spaced in transverse series, with conical cusp, only a little longer and sharper in adult males than in females; the bases ovoid transversely.

First and second dorsals either confluent at base or separated by a short interspace without thorns; second dorsal extending nearly to tip of tail in specimens seen, with only faint indication of separate caudal membrane. Pelvics rather strongly scalloped around the concavity; anterior margin 51 % as long as distance from its own origin to rear tip of pelvic on one female, 43 % on a male; anterior lobe broadly subtriangular; posterior lobe weakly convex and only faintly scalloped; rear tip narrowly rounded in both sexes.

Anterior rays of pectorals extending about 55–60 % of distance from level of fronts of orbits toward tip of snout.

Color. Described as having upper surface plain fawn color, slate-gray or clay-gray when fresh (changing to chocolate brown in formalin). Lower surface uniformly white in some,[64] but others with a gray longitudinal band along tail and a gray blotch on either side of cloaca, or with outer posterior parts of pectorals and posterior lobes of pelvics

63. Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 46.
64. So described by Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 46) on specimens from between Denmark and southern Norway.

broadly edged with dark gray, a dark gray spot near tips of anterior pelvic lobes, and irregular dark markings below tip of snout.

Size. This is one of the larger Skates of the region, males maturing sexually when they are about 970 mm long (about 38½ in.). The maximum recorded length is about 1,117 mm (44 in.), but the size at hatching is not known.

Developmental Stages. The egg case is about 107 mm long by 77 mm wide, exclusive of the horns; its walls have longitudinal striae and cross-hatching much as in *R. radiata*; the lateral flanges are margined with fine threads; the tip of each of the longer pair of horns is produced into a fine point.[65]

Habits. R. lintea is confined to water of at least moderate depth, all recorded captures having been from 80 fathoms or deeper. Available evidence fails to establish the lower limits of its usual range, but it has been taken most often in water shoaler than 350 fathoms.

The bottom temperatures recorded for stations where *R. lintea* has been taken have ranged from 3.3° C (38° F) off West Greenland to about 6° C. Thus its thermal range appears to average a little higher than that of *R. fyllae* (p. 199) and considerably higher than that of *R. hyperborea* (p. 211).

The nature of its teeth suggests that *R. lintea*, like *R. hyperborea*, feeds chiefly on active prey, such as small fishes and crustacea, but no examination appears to have been made of its stomach contents.

Range. Fishing banks off southwestern Norway, Faroe-Shetland Bank, Skagerrak between southern Norway and Denmark, slope west of Ireland, and Iceland in the eastern North Atlantic;[66] also on the West Greenland side of Davis Strait.

Occurrence in the Western Atlantic. The only reason for mentioning *R. lintea* here is that its range extends to West Greenland, where three specimens have been taken at depths of 210–318 fathoms in bottom temperatures of 3.3–3.9° C.[67] Its restriction to bottom waters warmer than 3° C, and its apparent preference for depths less than 400–500 fathoms, seem likely to prevent its dispersal to the American slope.

Synonyms and References:

Raja[68] *lintea* Fries, K. svensk. VetenskAkad. Handl. (1837), 1838: 154 (descr., length, color, but not synonyms; off Bohuslan, Sweden); Müller and Henle, Plagiost., 1841: 147 (descr., after Fries, 1838); Ekstrom, Göteborg VetenskSamh. Handl., (3) *1*, 1850: 41 (listed, Kattegat, but probably Skagerrak in reality); Kröyer, Danmark's Fisk., *3* (2), 1853: 1005 (descr., meas., ill., but not synonyms; off Stavangar, Norway, but Kattegat ref. probably Skagerrak in reality); Nilsson, Skand. Fauna, Fish., 4, 1855: 738 (descr., but not synonyms, off Bohuslan, Sweden); Malm, Öfvers. Vet. Akad. Forh. Stockh., 1857: 193 (size off Jaederen, Norway); Duméril, Hist. Nat. Poiss., 1, 1865: 557 (descr., size, but not synonyms, Sweden); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 466 (descr., off Sweden); Olsson, Acta Univ.

65. For description and photograph of an egg case taken from a fish from Iceland, see Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 45, pl. 27, fig. b).

66. *R. lintea* has been reported from South Africa also (Barnard, Ann. S. Afr. Mus., *21* [1], 1925: 72). But the Skate in question is clearly a different species, namely *R. leoparda* von Bonde and Swart 1924 (see Norman, Discovery Rep., *12*, 1935: 44).

67. The localities are: Lat. 66°35′ N, Long. 56°38′ W; Lat. 66°45′ N, Long. 56°39′ W; and Lat. 66°53′ N, Long. 56°17′ W. For details, see Jensen (Mindeskr. Steenstr. Føds. Kbh., *2* [30], 1914: 28).

68. Also spelled *Raia*.

lund. (1871), 7, 1871–1872: 12 (listed); Collett, Forh. VidenskSelsk. Krist. (1882), 29, 1883: 4 (depth, Jaederens-Rev, near Stavanger, Norway); Lilljeborg, Sverig. Norg. Fisk., (7) *3* (2), 1891: 580 (descr., but not synonyms, off Bohuslan, and Norwegian fishing banks; but ref. to Kattegat probably Skagerrak in reality); Collett, Forh. VidenskSelsk. Krist., 1905: [7], 122 (diagn., depth, banks off Jaederen, Norway, Skagerrak); Smitt, Hist. Scand. Fish., 2nd ed., 1895: 1117 (descr., ill., but not synonyms, off S. Norway, but ref. to Bohuslan probably Skagerrak); Jensen, in Schiødte and Hansen, Zool. Danica, *2* (12), 1907: 338, pl. 32, fig. 2 (descr., ill., size, range, depth); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 329 (descr., but color probably not correct); Jensen, Mindeskr. Steenstr. Fods. Kbh., *2* (30), 1914: 26, 38, fig. 12 (refs., descr., color, ills. teeth, depths, temps., chart of distrib., W. Greenland); Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 45, pls. 25–27 (descr., ills. egg case and adults, cf. other species, range); Faune Ichthyol. Cons. int. Explor. Mer, 1930: pl. not numbered (descr., ill., range); Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 46 (W. Greenland).

Leucoraia lintea Malm, Göteborgs och Bohuslans Fauna, 1877: 611 (descr., depth, banks off S. Norway).

Raja ingolfiana Lütken, Danish Ingolf Exped., *2* (1), 1898: 3, pl. 1 (descr., ill., depth, temp. off Holstenborg, W. Greenland); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 327 (descr., local., after Lütken, 1898).[69]

Not *Raia lintea* Barnard, Ann. S. Afr. Mus., *21* (1), 1925: 72 (equals *Raia leoparda* von Bonde and Swart [Fish. Mar. biol. Surv. S. Afr., Rep. 3 (1922), Spec. Rep. 5, 1924: 7, pl. 20, fig. 2] S. Afr.; see Norman [Discovery Rep., *12*, 1935: 44]).

Raja mollis Bigelow and Schroeder 1950

Figure 51

Study Material. Juvenile male, 262 mm long (type), from lower part of continental slope, south of southern Nova Scotia, Lat. 41°53′ N, Long. 65°35′ W,[70] 858 fathoms, in U. S. National Museum.

Distinctive Characters. R. mollis is characterized by the following features: a comparatively short tail,[71] a wedge-shaped anterior contour, no conspicuous thorns anywhere on its disc posterior to the scapular region or on its tail, and rostral projection from its cranium soft from base to tip. In general form and in prickliness of the upper and lower surfaces of the tail and of the upper surface of its disc, it resembles *R. spinicauda*, as well as females and juvenile males of *R. senta*. But it differs noticeably from *R. senta* in lacking large thorns anywhere on its disc posterior to the scapular region at a size at which the shoulder and mid-dorsal thorns are a conspicuous feature of *R. senta*. Equally convenient external field marks for *R. mollis*, as contrasted with *R. spinicauda*, are the considerably greater length of its tail, the prickliness of the entire breadth of the lower surface of its tail (not only the outer edges), the lack of large mid-dorsal thorns on its tail, and the fact that its two dorsal fins are confluent. In the softness of the rostral projection from its cranium it appears to be unique among the members of the genera *Raja* and *Breviraja* known from the western Atlantic. *Raja abyssicola* Gilbert 1895, known from one specimen from 1,588 fathoms off the coast of British Columbia, and *R. stellulata* Jordan and Gilbert 1880, from southern California to Alaska, appear to parallel *R. mollis* in this last respect. But each of them has a mid-dorsal row of thorns on the disc and on the tail.

69. Spelled *Raia*.

70. Albatross Station 2072, September 2, 1883.

71. Not longer from axils of pelvics to first dorsal fin than from axils of pelvics to front of orbits.

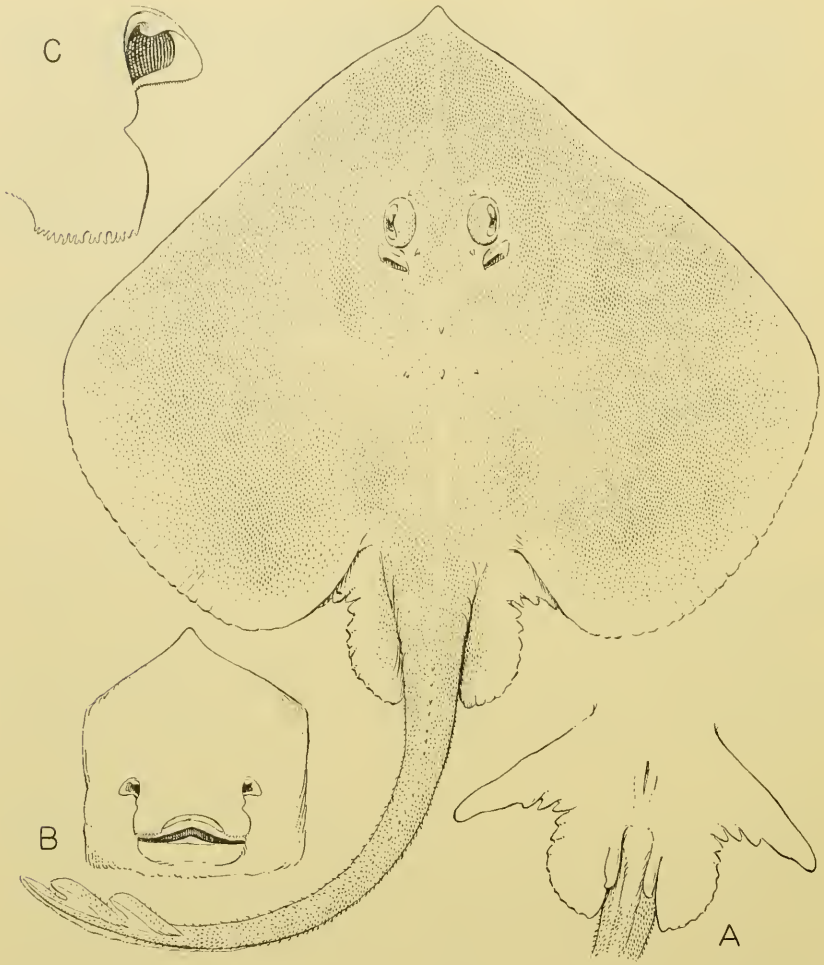


FIGURE 51. *Raja mollis*, juvenile male, 262 mm long, from lower part of continental slope off southern Nova Scotia, Lat. 41°53′ N, Long. 65°35′ W, in 858 fathoms (U. S. Nat. Mus., No. 33385, type). *A* Pelvic fins, ventral view. *B* Central part of anterior part of head, ventral view. *C* Nasal curtain and exposed nostril, about 3.6×.

Description. Proportional dimensions in per cent of total length. Juvenile male, 262 mm long, from Lat. 41°53′ N, Long. 65°35′ W (U. S. Nat. Mus., type, No. 33385).

Disc: extreme breadth 61.0; length 49.7.

Snout length: in front of orbits 14.9; in front of mouth 15.7.
Orbits: horizontal diameter 3.8; distance between 3.8.
Spiracles: length 2.1; distance between 7.1.
Mouth: breadth 8.0.
Exposed nostrils: distance between inner ends 8.6.
Gill openings: lengths, 1st 1.5; 3rd 1.5; 5th 1.0; distance between inner ends, 1st 13.2; 5th 8.8.
First dorsal fin: vertical height 2.3; length of base 4.4.
Second dorsal fin: vertical height 2.3; length of base 5.0.
Pelvics: anterior margin 10.3.
Distance: from tip of snout to center of cloaca 42.8; from center of cloaca to 1st dorsal 44.4; to tip of tail 57.2; from rear end of 2nd dorsal to tip of tail 3.4.
Interspace between: 1st and 2nd dorsals 0.0.

Disc about 1.2 times as broad as long, subangular in front; tip of snout slightly blunted, projecting a little; maximum anterior angle in front of spiracles about 115°; anterior margins of pectorals from close behind tip of snout nearly straight or weakly concave abreast of eye and spiracle;[72] outer corners broadly rounded; posterior margins strongly convex; posterior corners well rounded with curvature continuous to axils of pectorals. Tail with narrow lateral folds confined to posterior third; distance from center of cloaca to first dorsal fin about equal to distance from center of cloaca to tip of snout, and distance to tip of tail about 1.3 times that great. Distance from axils of pelvics to first dorsal a little greater (1.1) than distance from axils of pelvics to front of orbits.

Upper surface of disc (including skin above eyes) rugose with prickles or minute thornlets except close along posterior margins, some of them low and conical, others higher but straight, and others still higher, their tips very fine and curved rearward in varying degree; one or two somewhat larger thorns close in front of eye on juveniles,[73] but perhaps more numerous on adults; one blunt and slightly larger thorn inward from each spiracle, one on nuchal region, one on mid-dorsal line over pectoral girdle, and a smaller one on each shoulder (perhaps more on adults); other than these no sizeable thorns on disc; upper surface of tail rough with prickles slightly larger than those on disc, its median line also with an irregular row of somewhat larger thornlets scattered from opposite tips of pelvics for about a third of the distance toward the first dorsal, but without conspicuous thorns; upper surface of pelvics prickly on inner parts of posterior lobe but otherwise smooth; dorsal fins prickly; caudal membrane with a few prickles. Lower surface smooth on disc, pelvics, and root of tail; but remainder of tail close-set with small thornlets rearward to level of posterior end of second dorsal, similar to upper surface.

Snout in front of orbits about 3.9 times as long as distance between orbits, its

72. The two sides of our specimen differ slightly in this respect.
73. One such thorn on one side of our specimen, two on the other.

length in front of mouth about 1.8 times as great as distance between exposed nostrils. Orbit about as long as distance between orbits and about 1.8 times as long as spiracle. Distance between inner ends of first gill openings about 1.6 times as long as distance between exposed nostrils, that between fifth gills about $^2/_3$ (67 %) as long as distance between first gills; first gills about 1.5 times as long as fifth gills, about 19 % as long as breadth of mouth. Nasal curtain fringed, but edge of expanded posterior (outer) margin of nostril smooth or nearly so. Mouth nearly straight on juvenile male, probably so on females also, but perhaps more arched on mature males.

Teeth $^{56}_{54}$; with low conical cusp; bases about as long anteroposteriorly as they are broad transversely, closely crowded in quincunx. Teeth of mature specimens not seen.

First and second dorsal fins about equal in size, confluent at base without definite interspace, their shape as shown on Fig. 51. Caudal membrane posterior to second dorsal about $^3/_4$ (77 %) as long as base of first dorsal. Pelvics deeply concave outwardly, strongly scalloped around concavity; anterior margin nearly as long (90 %) as distance from pelvic origin to rear tip; anterior lobe spatulate, rounded at tip; posterior lobe moderately rounded outwardly, its inner margin straight; tip well rounded, extending rearward about $^1/_5$ (21 %) of the distance from axil of pelvic toward first dorsal.

Rostral cartilage extending nearly to tip of snout; so soft and flexible that it can hardly be felt, but visible against a strong light. Tips of anterior rays of pectorals falling a little short of level of tip of rostral cartilage.

Color. Upper surface of disc, tail and pelvics light grayish brown (after many years in alcohol), but either side of rostral ridge pale yellowish, perhaps translucent in life; no dark markings. Lower surface pale yellowish without markings.

Size. It is not known how large this Skate may grow; the only specimen seen is a juvenile male, its claspers reaching only $^2/_3$ of the distance rearward along the inner margins of the pelvics.

Habits. The great depth at which this one known specimen was trawled (858 fath.), plus its absence from the catches of Skates that are made along the slopes of the fishing banks off Nova Scotia and the Gulf of Maine, mark this as a deep-water species, probably confined to depths greater than 200–300 fathoms.

Range. Known only from the lower part of the continental slope off southern Nova Scotia.

Reference:

Raja mollis Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103*, 1950: 388 (descr., ill., continental slope off S. Nova Scotia).

Raja ocellata Mitchill 1815

Big Skate, Eyed Skate, Winter Skate

Figures 52, 53, 54

Study Material. Thirty-two specimens, from about one-fourth grown to mature, of both sexes, from the Massachusetts Coast and Georges Bank, in Harvard Museum of

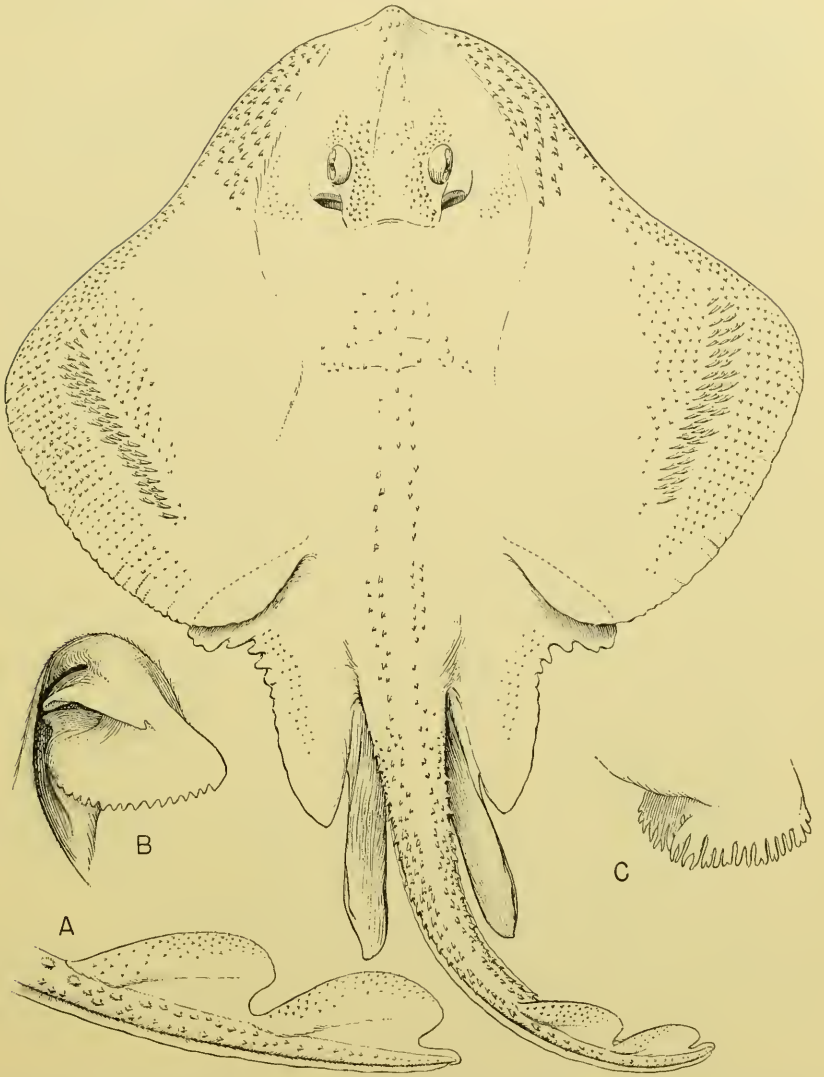


FIGURE 52. *Raja ocellata*, male, 809 mm long, from Nahant, Massachusetts (Harv. Mus. Comp. Zool., No. 352) *A* Side view of posterior part of tail of same, about 0.6×. *B* Nostril of same, about 5.7×. *C* Margin of left nasa curtain of same, about 5.7×.

Comparative Zoology; also two eggs with embryos, one of them still with small yolk sac, the other about ready to have hatched.

Distinctive Characters. Among the Skates of the geographic province where *R. ocellata* occurs, the ocellar spots usually present on the upper surface of its disc (p. 246) are a reliable means of identification for specimens that have them. However, specimens that lack these spots resemble *R. erinacea* so closely when small that the only certain means of distinguishing one from the other is by the number of series of teeth, *R. ocellata* having at least 80[74] series in the upper jaw (usually 90–100), *R. erinacea* never more than 66 (usually less than 54). Adults of the two species can also be separated by size, *R. ocellata* not maturing until it reaches a length of at least 25–26 inches whereas *R. erinacea* matures at 18–20 inches, its maximum length being only about 21 inches. What is said on p. 178 as to the differences between *R. erinacea* and *R. fyllae* applies equally to *R. ocellata.*

R. ocellata, like *R. erinacea*, falls closest to *R. naevus* Müller and Henle 1841 among European Skates in shape of disc, relative length of tail, distribution of thorns, loss of the mid-dorsal row of thorns with growth, and the frequent presence of a large ocellar spot on the upper inner part of each pectoral. But the disc and anterior part of the tail are thornier in *R. ocellata*, especially on females, and the skin of its disc is smooth between the thorns, whereas on *R. naevus* it is generally prickly between the thorns. *R. ocellata* does not bear a close resemblance to any Skate described from the South Atlantic or from the Pacific Coast of North, Central, or South America.

Description. Proportional dimensions in per cent of total length. Female, 806 mm (Harv. Mus. Comp. Zool., No. 359). Male, 809 mm, (Harv. Mus. Comp. Zool., No. 352) from Massachusetts.

Disc: extreme breadth 60.6, 64.8; length 46.6, 49.3.
Snout length: in front of orbits 11.6, 10.6; in front of mouth 11.5, 11.1.
Orbits: horizontal diameter 3.5, 4.1; distance between 5.3, 5.9.
Spiracles: length 3.6, 3.5; distance between 7.8, 8.0.
Mouth: breadth 9.9, 10.1.
Nostrils: distance between inner ends 7.6, 6.9.
Gill openings: lengths, 1st 2.0, 2.0; 3rd 2.3, 2.3; 5th 1.7, 1.7; distance between inner ends, 1st 16.0, 17.4; 5th 8.8, 8.4.
First dorsal fin: vertical height 3.2, 3.3; length of base 7.6, 7.5.
Second dorsal fin: vertical height 3.0, 2.6; length of base 6.7, 6.7.
Pelvics: anterior margin 11.7, 14.8.
Distance: from tip of snout to center of cloaca 50.6, 49.2; from center of cloaca to 1st dorsal 33.7, 34.7; to tip of tail 49.4, 50.8; from rear end of 2nd dorsal base to tip of caudal 1.5, 1.9.
Interspace between: 1st and 2nd dorsals 0.0, 0.0.

74. Bigelow and Schroeder (Bull. U. S. Bur. Fish., *48*, 1936: 324) give as few as 70, but re-examination of the specimens on which this count was based showed that the number should have been stated as 80.

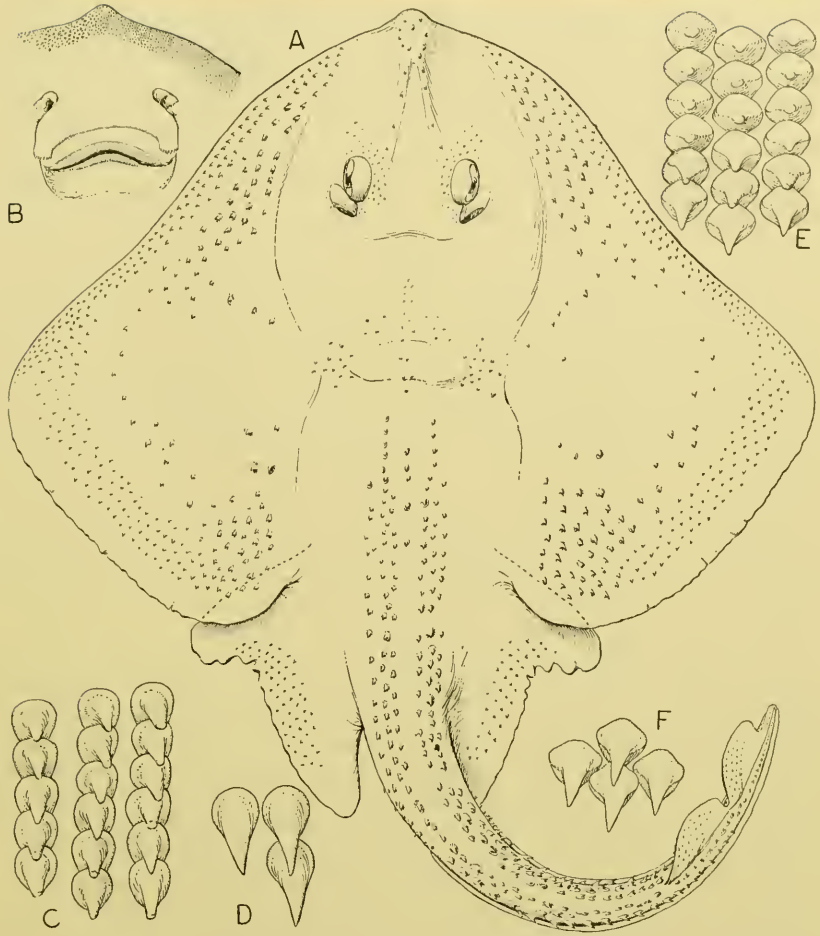


FIGURE 53. *Raja ocellata*. *A* Female, 806 mm long, from southern Massachusetts (Harv. Mus. Comp. Zool., No. 359). *B* Lower surface of anterior part of head of male pictured in Fig. 52. *C* Upper teeth (front rows) of another adult male from Nahant, Massachusetts (Harv. Mus. Comp. Zool., No. 1136), about 7×. *D* Upper teeth from rearmost rows of same, about 7×. *E* Upper teeth (front rows) of adult female from Waquoit, Massachusetts (Harv. Mus. Comp. Zool., No. 548), about 7×. *F* Upper teeth of 10th and 11th rows of same, about 7×.

Disc about 1.2–1.3 times as broad as long, obtuse in front (averaging a little more so than in *R. erinacea*, p. 179); maximum anterior angle in front of spiracles 135–150°, irrespective of size; anterior margins weakly concave for a short distance close behind

tip of snout, then weakly convex rearward in small specimens, weakly concave opposite spiracles in partly grown of both sexes and in adult females, and a little more deeply so in adult males; outer and posterior corners broadly rounded, posterior margins gently convex. Axis of greatest breadth on adult males about 75 % of distance back from snout toward axes of pectorals, about 70 % on adult females. Tail with narrow lateral folds beginning posterior to axils of pelvics by a distance equal to about twice diameter of eye and extending to extreme tip; its length from center of cloaca to origin of first dorsal about 80 % as great as distance from center of cloaca to tip of snout on small and medium-sized specimens, about 70 % on large; extreme length of tail from center of cloaca about 1.0–1.2 times as great as distance from cloaca to snout.

Young specimens with 3–4 thorns on each shoulder and with others between orbits, surrounding eyes, and along margins of rostral ridge to tip of snout; a row of 12–16 thorns, about uniform in size, along midline of disc from nuchal region; 16–18 on tail to first dorsal fin, this row flanked by a second less regular row of slightly smaller thorns from close behind pectoral girdle and by a third irregular row of smaller thorns low down on either side of midsector of tail. Outer anterior parts of pectorals loosely strewn with small thorns, but posterior corners and considerable areas along either side of mid-dorsal ridge bare.

With growth, the thorns of the mid-dorsal row are lost from both the disc and tail,[75] and those between the orbits decrease in number and relative size, while the bare areas expand over the inner parts of the pectorals and abreast of the spiracles, eyes, and rostral ridge; however, the thorns on the shoulders increase in number and a thorny area develops on the central part of the posterior lobe of each pelvic.

Specimens that are $^1/_2$–$^2/_3$ grown have a patch of thorns on the tip of the snout, a regular or irregular series on each edge of the rostral ridge, a patch of small thorns in front of the orbit, a row around its inner margin, several larger ones (one usually noticeably larger) just behind the orbit, and a few small ones between the orbits. The pectorals are rough with small thorns and prickles along the anterior margins nearly to the posterior corners, with larger thorns scattered abreast of the spiracles and eyes and on the posterior parts. Each shoulder bears a roughly triangular patch of medium-sized thorns (variable in number), the outermost 2–3 usually considerably largest; also, there are 2–3 irregular rows of medium-sized thorns with radiate bases along either side of the mid-dorsal line from the pectoral girdle rearward past the first dorsal fin,[76] these thorns decreasing in size and in regularity rearward, not much larger in any one of these rows than in the other rows, and those lowest down on the sides of the tail smallest. The central parts of the posterior lobes of the pelvics are prickly at first but later become thorny. The first and second dorsals are prickly. Otherwise the skin is smooth, with extensive bare areas along either side of the mid-dorsal zone, alongside the spiracles and eyes, and between the rostral ridge and the anterior radial cartilages of the pectorals.

75. Twenty inches is the greatest length at which a definite midrow of thorns still persists in any specimen that we have seen; they are usually lost by the time specimens are half-grown.
76. Sometimes four rows locally on one side of the tail or the other.

By maturity the thorns decrease in number on the shoulder regions, around the eyes, and on the rostral ridge and the bare areas expand over most of the inner parts of the pectorals, but mature females develop large thorns, widely spread, over the posterior corners of the pectorals, the thorny areas expanding over the posterior lobes of their pelvics; a few thorns also appear on the anterior lobes. Mature males develop 4–6 irregular rows of conspicuous thorns over a narrow triangular area from the tips of the pectoral cartilages back about to the level of the eyes. Alar spines of mature males are ordinarily in three rows, these appearing when the claspers extend about a third of the way back from the tips of the pelvics toward the end of the tail; 19–21 spines in each of the two inner rows, 10–12 in the outermost. The lower surface is smooth in small specimens, but the tip of the snout becomes prickly with growth, as does a narrow band along the anterior margins reaching rearward to the level of the mouth in half-grown specimens and for some distance posterior to the mouth in adults.

Snout in front of orbits about 2.0–2.3 times as long as distance between orbits; its length in front of mouth 1.4–1.7 times as great as distance between exposed nostrils. Orbit about 65–70 % as long as distance between orbits, and 1.0–1.2 times as long as spiracle. Distance between first gill openings 2.1–2.5 times as long as distance between exposed nostrils, between fifth gill openings 1.0–1.3 times; first gill openings 1.0–1.2 times as long as fifth and about 18–22 % as long as breadth of mouth. Nasal curtain fringed, expanded posterior (outer) margin of nostril with very short fringe, sometimes irregular and easily overlooked. Mouth but little arched, hardly more so in males than in females.[77]

Teeth $\frac{72-110}{74-110}$; those of young and of females to maturity rounded, or sometimes with blunt cusp faintly indicated, and close-set in quincunx; those of mature males with high conical cusp blunted at tip, more widely spaced in transverse series.[78]

First and second dorsals similar in size and shape, the two confluent at base. Caudal membrane posterior to second dorsal about $\frac{1}{4}$–$\frac{1}{5}$ as long as base of first dorsal. Pelvics moderately concave outwardly, weakly scalloped around the indentation; anterior margin about 59–66 % as long as distance from its own origin to rear tip of pelvic; anterior lobe broad, including 4–5 radial cartilages besides the first and stoutest; posterior lobe weakly convex outwardly, its rear corner narrowly rounded. Claspers of sexually mature males extend about halfway from axils of pelvics toward tip of tail.

Anterior rays of pectorals extending forward about 80 to 90 % of distance from level of fronts of orbits toward tip of snout in most specimens, reaching almost opposite tip of snout in others.

Color. Light brown above, with varying numbers of rounded blackish spots; on half-grown specimens and larger, the spots usually about 3–6 mm in diameter and scattered 8–12 mm apart on disc, pelvics, tail, and claspers of mature males; also, outer

77. In *R. erinacea* at maturity the lower jaw is considerably more arched in males than in females.

78. In maturing males the replacement of rounded teeth by conical ones takes place when the claspers are about half-grown; in a specimen of about 800 mm the lower rows of teeth are still of the immature shape, whereas in the upper jaw the teeth in successive rows are progressively more and more conical from front to rear; i. e., from the older rows of teeth to those more recently formed.

or posterior part of each pectoral often with 1–4 black or dark brown ocellar spots edged with white and varying from round to oval; sometimes 1–2 smaller ones nearby; size, arrangement and number of these spots varying from specimen to specimen; sometimes each pelvic with a similar ocellar spot. Each side of snout in front of eyes with a whitish translucent area. Lower surface usually white but marked with irregular pale brownish blotches of various sizes[79] on posterior part of disc and along tail of some specimens.

Size. Specimens so recently hatched that their abdomens are still more or less swollen with yolk range from about 112–127 mm in length, apart from whatever remnant of the embryonic caudal filament may still persist. In a male of 665 mm the claspers reach about to the tips of the pelvics; in one of 715 mm they extend about one-third of the way from the axils of the pelvics toward the tip of the tail; and halfway in one 810 mm long. All of the males are sexually mature by the time they have reached a length of about 750 mm, some by 620 mm.[80] The longest female we have seen measured 806 mm, the longest male 834 mm; the maximum recorded length is about 43 inches (1,090 mm).[81] On the average, males about 20 inches long weigh 2 pounds; 30 inches, 7 pounds; 32 inches, 9 pounds. Females about 20 inches long weigh 2 pounds; 25 inches, 4 1/2 pounds; 28 inches, 6 1/2 pounds.[82]

Developmental Stages. The greenish brown or brownish olive egg cases are about 55–86 mm in length by 35–52 mm in breadth, excluding the horns, and northern specimens average larger than southern ones.[83] The end with the shorter pair of horns is weakly concave, that with the longer horns straight or weakly convex and more or less ragged. The horns are strongly flattened and each is described as having a slit on its outer edge near its tip.[84] The longer pair of horns on egg cases that have been laid is usually about 1.5 times as long as the shorter pair and about 1.5 times as long as the egg case, but the extreme tips are likely to have been broken off. The outer margin, close to each of the shorter pair of horns of newly laid cases, bears a short slender spur, the edge of which, like the remainder of the lateral border, is fringed with a series of silky filaments that are tangled and matted together. But these as well as the spurs are so easily torn off that only tufts remain here and there on cases that have been deposited for more than a brief period. No doubt the filaments serve as anchors.[85]

Embryos ready for hatching already show the distinctive characters of the species so clearly that they are easy to identify.

79. 15 by 15 mm to 35 by 74 mm in one specimen.
80. This is the case in the Block Island region, according to the Bingham Oceanographic Laboratory.
81. A maximum length of six feet credited to this species by Hildebrand and Schroeder (Bull. U. S. Bur. Fish., *43* [1], 1928: 58) actually referred to *R. laevis*.
82. We are indebted to the Bingham Oceanographic Laboratory for these data on maximum recorded lengths and on length-weights.
83. 75–86×44–52 mm from Nova Scotia (Vladykov, Nat. canad., *63*, 1936: 216); 66–70×45–45 mm for two from Provincetown, Massachusetts; and 64–70×35–42 mm from New York (Breder, Copeia, 1937: 182).
84. These slits, recorded by Wyman (Mem. Amer. Acad. Arts Sci., N. S. *9* [2], 1864: 31) are not visible on the preserved specimens we have seen.
85. For an account, with exellent illustrations, of the lateral spurs and filaments and of the embryonic development, see Wyman (Mem. Amer. Acad. Arts Sci., N. S. *9* [2], 1864: 32, 33, fig. 1, 2–10).

Habits. The Eyed Skate has much the same diet as *R. erinacea* (p. 183), crabs (*Cancer*) being the chief item where available; but they also take annelids, shrimps, bivalves, and whatever small fish they can capture.[86] A specimen opened by us recently contained the body of an ascidian (*Boltenia*), the bristles from an annelid (apparently *Aphrodite*), vertebrae of small fishes, and two sizeable pebbles. Another, 31 inches long, taken off Massachusetts, was reported to have been full of beach fleas (*Talitrus*); one caught off northern Nova Scotia had eaten butterfish, cunners, and squid.[87]

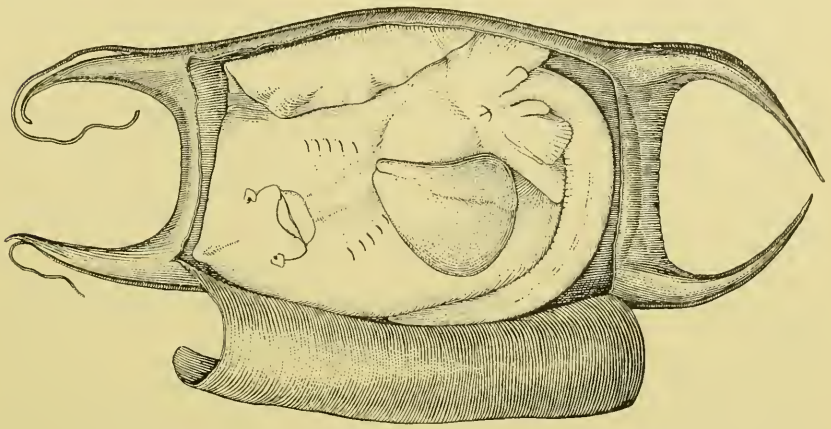


FIGURE 54. *Raja ocellata*, egg case, opened to show enclosed embryo, from Woods Hole, Massachusetts, about 1×.

This Skate is closely confined to sandy or gravelly bottoms. No doubt this preference for hard bottom is the explanation for its reputed absence from Buzzards Bay as contrasted with its regular occurrence in season at depths no greater in Vineyard Sound nearby.

Its depth range is wide, for while it is often speared from the wharves in the northernmost part of its range[88] and is taken in pound nets farther south, it is taken down to 50–60 fathoms on the offshore fishing banks northward and eastward of Nantucket. But most of those we have seen from many otter trawl hauls off the southern New England Coast were taken shoaler than 40 fathoms.[89] The upper limit to its optimum thermal

86. The list at Woods Hole includes smaller skates, eels, herring (*Clupea*), alewives (*Pomolobus pseudoharengus*), bluebacks (*Pomolobus aestivalis*), menhaden (*Brevoortia*), smelt (*Osmerus*), launce (*Ammodytes*), chub mackerel (*Pneumatophorus*), butterfish (*Poronotus*), cunners (*Tautogolabrus*), sculpins (*Myoxocephalus*), silver hake (*Merluccius*), tomcod (*Microgadus*), and hake (*Urophycis*).
87. Cornish, Contr. Canad. Biol. (1902–1905), 1907: 81.
88. At Prince Edward Island (Cornish, Contr. Canad. Biol. [1906–1910], 1912: 79).
89. No specimens of *R. ocellata* were taken in 44 hauls made by the EUGENE H. in 47–67 fathoms between Long. 71°54′ and 71°15′ W, January 27–February 3, 1950, and only one was taken deeper than 40 fathoms by the ALBATROSS III in 63 hauls down to 240 fathoms between Long. 67°10′ and 72°20′ W, May 11–18, 1950.

range is probably near 18–19° C (about 64–66° F), for it tends to withdraw from very shallow water along southern New England in early summer when the temperature has risen to about that value and to reappear there and near New York in early autumn[90] when the water has cooled to about that same temperature. At the opposite extreme it is taken frequently on the Nova Scotian Banks in water colder than 5° C (41° F).[91] The majority of the population inhabits salinities ranging from about 34.4 to 32 $^{0}/_{00}$. Some individuals may even be exposed to salinities as low as 29 $^{0}/_{00}$ in the southern side of the Gulf of St. Lawrence, if any remain through the critical season (April–June) and in shoal enough water, around the shores of the Gulf of Maine, and possibly in the immediate vicinity of New York and at the mouth of Chesapeake Bay. One has even been reported from the Delaware River opposite Philadelphia.

The stock inhabiting depths of 10 fathoms or more appears to be resident the year-round there. But it has been known for a long time that the coastwise fringe of population tends to work shoreward with the autumnal decrease in temperature in the southern part of its range and to withdraw again into deeper (i. e., somewhat cooler) water as bottom temperatures again approach the summer maximum. Thus all the dated records of its presence inshore between Chesapeake Bay and New Jersey have been between December and early June.[92] Similarly, it appears in shallow water from Cape Cod to New York in the first part of October, and larger numbers are said to be taken in Massachusetts Bay in winter than in summer. But it is present inshore regularly during summer in Passamaquoddy Bay at the entrance to the Bay of Fundy, in Nova Scotian waters, and around Prince Edward Island in the south side of the Gulf of St. Lawrence (p. 249).

It is now known that some of the population inhabiting the shore waters along southern New England carry out extensive coastwise journeys. Thus three tagged a few miles off Block Island, Rhode Island, in June 1946[93] were recaptured 80–120 miles to the westward.[94]

This Skate breeds throughout its geographic range.[95] In Nova Scotian waters it deposits its eggs from summer into autumn,[96] apparently at the same season in the Gulf of Maine; off southern New England it appears that eggs are deposited throughout

90. Occasional specimens have been reported as summering in shoal water off the eastern end of Long Island, where the bottom temperature may rise to 18–19° C (about 64–66° F) at its seasonal maximum. And we have caught them in partially enclosed waters along outer Cape Cod in August.
91. *R. ocellata* has been reported from the Newfoundland Banks in temperatures as low as −0.4 to −1.1° C (31–30° F). But the identity of the specimens has been questioned.
92. Only a few of the published records for it along this sector have been dated.
93. Four were recaptured out of a total of 400 fish tagged. We are indebted to Daniel Merriman for these records.
94. One off Fire Island, New York, October 1946, one in New York Bay (Staten Island) in November 1948, and one in Sandy Hook Bay, New Jersey, in December 1946. The fourth recapture was in June 1947, near Watch Hill, Rhode Island, about 15 miles distant from the locality where tagged.
95. Eggs have been taken either from the mother or by dredge or have been found on the shore near Sable Island off Nova Scotia, in Halifax Harbor, off the coast of Maine, at the tip of Cape Cod, in Vineyard Sound, southern coast of Massachusetts, off New York Harbor, and on the Delaware Coast.
96. Eggs have been found in September in females trawled near Sable Island and caught off the coast of Maine; empty cases have been found in Halifax Harbor as early as the end of October. An egg case with advanced embryo, taken in Vineyard Sound late in August, 1936, is included in our Study Material.

the year, for they have been found in *ocellata* collected in Block Island Sound in April, May, August, November and February. A female, probably of this species, that was brought to Woods Hole laid an egg in the aquarium on January 16 and laid six more within a few days; the embryos were well advanced by May 12, but none had hatched by June 16, after which they were lost.[97]

Numerical Abundance. *R. ocellata* has been characterized as common or as abundant about as often for one sector of its range as for another. But the only precise information regarding its numerical abundance with which we are acquainted is that one trawler, in 37 hauls, took 71 *R. ocellata* out of a total of 495 Skates of all kinds on Georges Bank in September 1929,[98] and that another trawler obtained an average hourly catch of 22.4 pounds with an 80-foot trawl in Long Island Sound from August 1943 to January 1944,[99] or about five specimens per hour, if the average weight were about five pounds. This would correspond to about 300 specimens per square mile if the bottom strip swept by the trawl were about 50 feet broad, if the distance covered were two sea miles per hour, and if the trawl caught every Skate that lay in its path, which it certainly did not.

Range. Continental waters of the western North Atlantic from the offing of northern North Carolina to northern Nova Scotia, southern side of the Gulf of St. Lawrence, and Newfoundland Banks.

Details of Occurrence. *R. ocellata* is generally distributed, if not very common, along the southern side of the Gulf of St. Lawrence from the Cape Breton shore to the Magdalen Islands, including Prince Edward Island, and it has been described as very common at Canso. It has been reported also by name for various localities along the periphery of the Banks of Newfoundland and has been identified from the southern part recently.[100] To the southward it has been taken at Banquereau Bank, Sable Island Bank, and Halifax, Nova Scotia, and fishermen are familiar with it throughout this general region to the mouth of the Gulf of Maine. It is well known in the Bay of Fundy, including the Passamaquoddy Bay region, and it has been taken at nearly all localities around the northern and western parts of the Gulf of Maine, in Massachusetts Bay, and off Cape Cod where information is available as to the composition of the local fish fauna. On Georges Bank,[101] as well as on Nantucket Shoals, it forms an appreciable proportion of the Skate population. It occurs regularly in season (p. 248) along the coast of southern New England, in the vicinity of New York (Sandy Hook and lower New York bays), along New Jersey,[102] Delaware, and the Atlantic Coast of Virginia, and within the mouth of Chesapeake Bay; it also occurs on the offshore fishing grounds off New York and New Jersey, and it has been recorded in 16 fathoms off Bodie Island, North Carolina. But we find no report and have seen no specimen of it from farther south.

97. This specimen was reported as *R. laevis* (Seal, Aquarium, *2* [10], 1914: 105); but it seems likely that it was an *ocellata* because of its size (15 in. wide) and because of the season at which it deposited its eggs.
98. Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324.
99. Merriman and Warfel, Trans. 9th N. Amer. Wildl. Conf., 1944: 234.
100. Information from Wilfred Templeman.
101. 14 % of the Skates caught on one trip to Georges Bank in September 1929 were *R. ocellata*.
102. Reported from many localities, including Delaware Bay.

Synonyms and References:

Raja[103] *ocellata* Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 477 (descr., New York); Storer, Boston J. nat. Hist., *2*, 1839: 543 (descr., food, Mass.); Rep. Fish. Rept. Birds Mass., 1839: 191 (Mass.); Linsley, Amer. J. Sci., *47*, 1844: 77 (listed, Connecticut); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 510 (diagn., New York and Conn.); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed, Atlant. Coast N. Amer.); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 455 footnote (ref.); Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: 53 (Mass.); Goode and Bean, Bull. Essex Inst., *11*, 1879: 29 (Maine); Bean, Proc. U. S. nat. Mus., *3*, 1880: 115 (Mass. locals.); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 40 (descr., size, egg cases); Bean, Rep. U. S. Comm. Fish (1882), 1884: 343 (listed, Woods Hole, Mass.); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed, N. Atlant. U. S.); Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 91, pl. 30 (mucous canal syst.); Jordan and Evermann, Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, Mass. northward); Bull. U. S. nat. Mus., 47 (1), 1896: 68 (descr., egg cases, New York and northward); Bumpus, Science, N. S. *8*, 1898: 58 (Woods Hole); Smith, Bull. U. S. Fish Comm., *17*, 1898: 89 (season, Woods Hole); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 10, fig. 30 (ill.); Bean, 6th Rep. For. Comm. N. Y., 1901: 382 (season, New York); Linton, Bull. U. S. Fish Comm., *19*, 1901: 274, 431 (food, parasites, Vineyard Sound); Bean, Bull. N. Y. St. Mus., 60, Zool. *9*, 1903: 49 (descr., season, food, New York); Fowler, Rep. N. J. Mus. (1905), 1906: 71, pl. 3 (size, cf. *R. erinacea*, ill., New Jersey); Tracy, 36th Rep. R. I. Comm. inl. Fish., 1906: 47 (season, Narragansett Bay;) Cornish, Contr. Canad. Biol. (1902–1905), 1907: 82 (nos., food, Canso, Nova Scotia); Fowler, Rep. N. J. Mus. (1907), 1908: 129 (descr., nos., season, New Jersey, Delaware Bay); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 11 (New England locals.); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 470 (Maine, Mass., New Jersey); Linton, Bull. U. S. Bur. Fish., *28*, 1910: 1201 (cestode parasite, Woods Hole); Tracy, 40th Rep. R. I. Comm. inl. Fish., 1910: 62 (season, food, Narragansett Bay); Fowler, Proc. Acad. nat. Sci. Philad., *63*, 1911: 5 (egg cases, Delaware); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Cornish, Contr. Canad. Biol. (1906–1910), 1912: 79 (nos., Prince Edward I.); Fowler, Proc. Acad. nat. Sci. Philad., *65*, 1913: 62 (listed, Virginia); Halkett, Check List Fish. Canad., 1913: 42 (listed, Maritime Provinces to New York); Nichols, Abstr. Linn. Soc. N. Y., 20–23, 1913: 91 (season, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., 31 (2), 1913: 738 (season, depth, food, parasites, Woods Hole); Fowler, Proc. Acad. nat. Sci. Philad., *66*, 1914: 353 (nos., Delaware); Wiegman and Nichols, Copeia, 3, 1914: 2 (season, female with egg, New York); Fowler, Copeia, 13, 1914: 2 (New Jersey); Proc. Acad. nat. Sci. Philad., *67*, 1915: 517 (Nova Scotia); Wiegman and Nichols, Copeia, 23, 1915: 43 (New Jersey); Fowler, Copeia, 27, 1916: 12 (New Jersey); Copeia, 31, 1916: 41 (New Jersey); Proc. Boston Soc. nat. Hist., *35*, 1917: 111 (color, thorn pattern, Maine and Mass.); Jordan, Copeia, 49, 1917: 87 (*diaphanes* replaces *ocellata*); Huntsman, Trans. roy. Soc. Canad., (3) *12* (4–5), 1918: 63 (temp., Gulf St. Lawrence); Fowler, Proc. biol. Soc. Wash., *32*, 1919: 72 (Delaware R.); Proc. Acad. nat. Sci. Philad., *71*, 1920: 293 (New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 145 (New Jersey); Cox, Contr. Canad. Biol. (1918–1920), 1921: 109 (S. side Gulf St. Lawrence); Fowler, Fish Culturist, *6*, 1927: 115 (listed, New Jersey); Dill, Edwards and Florkin, Biol. Bull. Woods Hole, *62*, 1932: 23 (blood);[104] Fowler, Proc. Acad. nat. Sci. Philad.. *89*, 1937: 304 (season, New Jersey).

Raia[105] *diaphanes* DeKay, Zool. N. Y., 4, 1842: 366, pl. 67, fig. 218 (descr., ill., New York); Storer, Mem. Amer. Acad. Arts Sci., N. S. *9*, 1867: 240, pl. 39, fig. 1; also Fishes Mass., 1867: 264, pl. 39, fig. 1 (descr., ill., size, nos., Mass.); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 339, pl. 22, fig. 1 (descr., ill., cf. *R. erinacea*); Huntsman, Contr. Canad. Biol. (1921), 1922: 57 (depth, season, Passamaquoddy Bay and Bay of Fundy); Breder, Copeia, 127, 1924: 28 (season, temp., near New York); Huntsman and Sparks, Contr. Canad. Biol., N. S. *2*, 1924: 102 (lethal temp.); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 8, 61, 65 (cestode parasites); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (2), 1925: 60 (descr., ill., habits, Gulf of Maine); Manter, Illinois biol. Monogr., *10* (2), 1926: 8 (parasites, Maine); Breder and Nichols, Zoologica N. Y., *9*, 1927: 23 (ill., season, food, near New York and south. New England); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 56 (descr., ill., season, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 30 (descr., egg cases, depth, season, Virginia to Gulf of St. Lawrence); Jordan, Manual Vert. Anim. NE U. S., 1929: 16 (diagn., New Jersey north); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (listed, E. coast

103. Sometimes spelled *Raia*. 104. Spelled *ocillata*. 105. Also spelled *Raja*.

U. S.); Babkin and Komarov, Contr. Canad. Biol., 7 (1–7), 1931: 13 (gastric juice, St. Andrews, New Brunswick); Huntsman, Contr. Canad. Biol., 7 (1–7), 1931: 4 (physiol., St. Andrews, New Brunswick); MacKay, Contr. Canad. Biol., 7 (1–7), 1931: 19 (physiol.); Smith, H. W., Amer. J. Physiol., *98*, 1931: 279–295 (excretion); Breder, Copeia, 1932: 31 (season, nos., Block Island); Anon., Rep. Newfoundland Fish. Res. Lab. (1931), 1932: 107 (listed, SW. side of Grand Bank); Dawson, Biol. Bull. Woods Hole, *64*, 1933: 33 (blood); Nichols, Contr. Canad. Biol., 7, 1933: 34, 449 (physiol.); Anon., Rep. Newfoundland Fish. Res. Lab. (1932), 1933: 125 (depth, temp., sal., Newfoundland and Nova Scotian Banks); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 21, 22 (descr., ill., range); Anon., Rep. Newfoundland Fish. Res. Lab. (1934), 1935: 77 (Banquereau, off Nova Scotia); Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51 (Nova Scotia); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324 (cf. *R. erinacea*, nos., Georges Bank); Smith, H. W., Biol. Rev. (Cambridge), *11*, 1936: 67 (blood serum); Vladykov, Nat. canad., *63*, 1936: 217 (descr., photos, season, egg cases, Nova Scotia, cf. other species); Nichols and Breder, Copeia, 1937: 182 (egg cases, cf. other species); Breder, Bull. N. Y. zool. Soc., *41*, 1938: 28 (listed, New York Harbor); Merriman and Warfel, Trans. 9th N. Amer. Wildl. Conf., 1944: 234 (nos., Long Island Sound); Bull. Bingham oceanogr. Coll., *11* (4), 1948: 134 (listed, off Rhode Island and Conn.).

Raja ocellata (in part) Duméril, Hist. Nat. Poiss., *1*, 1865: 539 (descr., but *R. eglanteria* perhaps included).

Raia diaphanes (in part) Lyman, 6th Rep. Mass. Comm. inl. Fish., 1872: 54 (*R. ocellata* probably included, because abundant April and May, south. Mass.).

Raja ocellata var. *ocellata* Garman, Proc. Boston Soc. nat. Hist., *17*, 1874: 177 (descr., size, Mass.).

Raja ocellata var. *diaphana* Garman, Proc. Boston Soc. nat. Hist., *17*, 1874: 177 (color variety).

Big Skate, Wilson, Bull. U. S. nat. Mus., 158, 1932: 403 (copepod parasite).

Raia scabrata Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 21, fig. 1 (ill., mislabelled).[106]

Probable Synonyms:

Raia batis Wyman, Mem. Amer. Acad. Arts Sci., N. S. *9*, 1864: 39, 1 pl. (descr., ill., egg cases, embryos and newly hatched); Ann. Mag. nat. Hist., (3) *14*, 1864: 399 (abstr. of Wyman, 1864); Amer. J. Sci., (2) *38*, 1864: 29 (abstr. of Wyman, 1864); Proc. Boston Soc. nat. Hist., *9*, 1865: 334 (abstr. of Wyman, 1864); Putnam, Amer. Nat., *3*, 1869: 621 (after Wyman, 1864).

Raja laevis Seal, Aquarium, N. Y., *2* (10), 1914: 105 (female with eggs, Woods Hole, winter, probably *R. ocellata* because of small size, see p. 249, footnote 97; not seen).

Doubtful References:

Raia diaphanes Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 510 (doubtful whether *R. ocellata* or *R. eglanteria*).

Not *Raja batis* Linnaeus, Syst. Nat., *1*, 1758: 231 (E. Atlant.).

Not *Raja ocellata, capite magno* . . . Russell, Fish. Coromandel, *1*, 1803: 5, pl. 8 (a Sting Ray of the genus *Aetobatus*).

Not *Raja diaphanes* Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 478 (equals *R. eglanteria* Bosc 1802; see p. 187); Ayers, Boston J. nat. Hist., *4*, 1843: 289, pl. 12, fig. 2 (season, near New York, ill. appears to be *R. eglanteria*, see p. 176).

Not *Raia batis* Storer, Rep. Fish. Rept. Birds Mass., 1839: 193 (equals *R. laevis* Mitchill 1817).

Not *Raia ocellata* DeKay, Zool. N. Y., 4, 1842: 369, pl. 65, fig. 212 (descr., ill., equals *R. eglanteria* Bosc 1802, see p. 176).

Raja olseni Bigelow and Schroeder 1951

Figure 54 α

Study Material. Immature male, 280 mm long, type, from the Gulf of Mexico, Lat. 27°25′ N, Long. 96°13′ W, 76 fathoms, Oregon St. 157, in U. S. National Mu-

106. This illustration was actually of a specimen of *R. ocellata* in the collection of the Harvard Museum of Comparative Zoology which we have examined.

seum; an immature male, 282 mm long, from Lat. 27°27′ N, Long. 96°17′ W, 65 fathoms, Oregon St. 158; 2 males and 2 females, 230–310 mm long, Lat. 30°02′ N, Long. 86°53′ W, 60 fathoms, Oregon St. 332, and two males each of 310 mm, from Lat. 30°02′ N, Long. 86°55′ W, 64 fathoms, Oregon St. 353.

Distinctive Characters. *Raja olseni* closely resembles *R. laevis* in general appearance and in lacking thorns along the midbelt of the disc from the level of the axils of the pectorals to the vicinity of the spiracles. But it differs from *laevis* in having an interspace between the dorsal fins nearly or quite as long as the base of the first dorsal (only 0.1–0.3 that long in *laevis*) and by having a fringe on the expanded outer margin of the nostril (smooth in *laevis*); also, the lateral folds along its tail extend only to the anterior third of the caudal fin, whereas in *laevis* they extend almost or quite to the extreme tip of the tail; the lower sides of its disc are prickly along the anterior edges and over the rostral cartilage (smooth on *laevis* of equal size), and its mucous pores are not marked with black as they are in *laevis*. It differs from *R. spinicauda* in its fringed nostril lobe, in its shorter tailfolds, in the interspace between its dorsals, and in having three rows of thorns on the tail (only one row on *spinicauda*).

Description. Proportional dimensions in per cent of total length. Male, 280 mm (U. S. Nat. Mus., type, No. 153556), and male, 282 mm (Harv. Mus. Comp. Zool., No. 37176), from the northwestern part of the Gulf of Mexico.

Disc: extreme breadth 69.0, 72.0; length 54.0, 58.2.

Snout length: in front of orbits 15.6, 17.4; in front of mouth 17.7, 19.5.

Orbits: horizontal diameter 4.4, 4.3; distance between 3.6, 4.3.

Spiracles: length 2.0, 2.3; distance between 6.3, 6.7.

Mouth: breadth 7.9, 8.2.

Nostrils: distance between inner ends 7.9, 8.3.

Gill openings: lengths, 1st 2.0, 2.0; 3rd 2.1, 2.1; 5th 1.6, 1.6; distance between inner ends, 1st 13.6, 14.2; 5th 7.3, 8.2.

First dorsal fin: vertical height 2.5, 2.5; length of base 4.3, 4.4.

Second dorsal fin: vertical height 2.4, 2.3; length of base 4.6, 4.4.

Pelvics: anterior margin 13.2, 13.5.

Distance: from tip of snout to center of cloaca 47.5, 49.3; from center of cloaca to 1st dorsal 30.4, 30.2; to tip of tail 52.5, 50.7; from rear end of 2nd dorsal base to tip of tail 9.0, 7.8.

Interspace between: 1st and 2nd dorsals 4.3, 3.9.

Disc about 1.3 times as broad as long, the maximum anterior angle in front of spiracles about 90°; anterior margins concave just posterior to tip of snout, weakly convex opposite eyes and spiracles, thence about straight rearward; outer corners narrowly rounded; posterior corners more broadly so; posterior margins gently convex. Axis of greatest breadth about 67 % of distance rearward from tip of snout towards axils of pectorals. Tail with a lateral fold low down on each side beginning posterior to axils of pelvics by a distance about $^4/_5$ as long as eye and ending opposite anterior

FIGURE 54α. *Raja olseni*, male, 280 mm long, from Gulf of Mexico, Lat. 27°25′ N, Long. 96°13′ W (U. S. Nat. Mus. No. 153556, type). *A* Posterior part of tail, about 1.5×. *B* Mouth and nostrils, about 2×. *C* Upper teeth, about 12×.

third of caudal fin; length of tail from center of cloaca to origin of first dorsal fin 0.61–0.67 as great as, to its tip 1.0–1.1 times as great as, distance from center of cloaca to tip of snout.

One to three small thorns immediately in front of orbit, one being on the inner and one or two on the outer margin, also one or two on inner rear margin of orbit, and sometimes one or two opposite middle of orbit; these are the only thorns or prickles on the disc; 13 to 16 thorns along midline of tail from a little in advance of axils of pelvics to first dorsal fin; three in interspace between first and second dorsals; also an additional row of thorns, widely and unevenly spaced, on each side of median row, beginning about opposite tip of pelvic and extending to opposite beginning of caudal fin; dorsals and caudal smooth. Lower surface with a narrow band of small prickles along anterior margin of disc from level of nostrils to tip of snout and also along rostral cartilage.

Snout in front of orbits 3.5–4.0 times as long as orbit, its length in front of mouth 2.2–2.3 times as great as distance between exposed nostrils. Orbit 1.9–2.2 times as long as spiracle; distance between orbits 1.0–1.2 times as great as length of orbit. Distance between first gill openings 1.7 times as great as distance between exposed nostrils, between fifth gill openings 1.0–1.1 times; first gill openings 1.25 times as long as fifth and about 0.25 as long as breadth of mouth. Nasal curtain fringed; expanded posterior (outer) margins of nostrils fringed. Upper and lower jaws moderately arched centrally.

Teeth $\frac{34-41}{34-40}$, close-set in quincunx, ovate, with a triangular cusp.

First and second dorsals similar in size and shape. Interspace between dorsals 0.9–1.0 as long as base of first dorsal. Caudal membrane from rear end of base of second dorsal about twice as long as base of first dorsal. Pelvics deeply concave, strongly scalloped along anterior side of excavation but only weakly so rearward; anterior margin about as long as distance from its own origin to rear tip of pelvic; anterior lobe moderately slender, including five radial cartilages besides the first stout one; posterior lobe moderately convex outwardly; rear tips abruptly rounded, extending about $^2/_7$ of the distance from axils of pelvics toward first dorsal; inner margin straight. Claspers falling well short of tips of pelvics on specimens seen.

Rostral cartilage firm, extending to tip of snout. Anterior pectoral rays reaching about halfway from level of front of orbits toward tip of snout.

Color. In life, upper surface dark olive brown with many small roundish obscure spots of darker brown on disc; a small dark spot, smaller than pupil, on each side of disc inward near its center; series of small whitish pores extending in 3 or 4 rows along midzone of back from region of pectoral girdle to axils of pelvics and onto tail in 1 or 2 rows; 2 rows extending rearward and outward on each side of disc posterior to scapular region; whitish pores also present opposite and in front of orbits, some extending toward outer margin of disc in sinuous rows. Below, jet black everywhere, but this pigment tending to diminish in intensity or disappear in preservative.

Size and Habits. Since all the males have very small claspers, it is probable that the species attains at least a moderately large size, possibly two feet or more in total length. Nothing is known of its habits except that it is apparently a moderately deep-water species.

Occurrence. It is known only from the northern and northwestern part of the Gulf of Mexico, as listed in Study Material.

Reference:

Raja olseni Bigelow and Schroeder, J. Wash. Acad. Sci., *41* (12), 1951: 386 (descr., ill., Gulf of Mexico).

Raja radiata Donovan 1807

Thorny Skate, Starry Skate

Figures 55, 56

Study Material. Fifty-seven embryos and adults of both sexes, 126 to 935 mm long, from: Norway; Egemonde and Tunugdliarfik Fjord, West Greenland; Grand Banks of Newfoundland; Halifax, Nova Scotia; Emerald Bank, Georges Bank and various localities within the Gulf of Maine, including the Bay of Fundy; off the continental slope from southwest of Georges Bank to New Jersey in 118–260 fathoms and off South Carolina in 74 fathoms; in the U. S. National Museum and Harvard Museum of Comparative Zoology.

Distinctive Characters. R. radiata is marked off from all other Skates of the North Atlantic by the large size of the thorns along the midline of the back from the nape to the first dorsal fin, plus the facts that not more than 10 large thorns are present on the tail posterior to the axils of the pelvics and that the anterior contour of the disc is very obtuse (anterior angle at least 110°). It is so closely allied to *R. doello-juradoi* of the Argentinian-Patagonian-Falklands region in the South Atlantic that no reliable criteria have been found to distinguish the one from the other.

Description. Proportional dimensions in per cent of total length. Male, 530 mm (Harv. Mus. Comp. Zool., No. 249). Female, 800 mm (Harv. Mus. Comp. Zool., No. 1139), from Nahant, Massachusetts.

Disc: extreme breadth 71.7, 74.5; length 52.8, 51.3.

Snout length: in front of orbits 13.0, 12.9; in front of mouth 14.0, 13.9.

Orbits: horizontal diameter 4.3, 3.8; distance between 5.1, 4.8.

Spiracles: length 3.0, 3.3; distance between 8.1, 8.0.

Mouth: breadth 10.1, 10.7.

Nostrils: distance between inner ends 9.5, 9.8.

Gill openings: lengths, 1st 1.9, 1.9; 3rd 2.1, 2.0; 5th 1.7, 1.9; distance between inner ends, 1st 17.0, 19.6; 5th 10.7, 12.2.

First dorsal fin: vertical height 3.0, 3.2; length of base 5.2, 5.1.

Second dorsal fin: vertical height 2.8, 2.8; length of base 5.9, 6.6.

Pelvics: anterior margin 13.2, 11.2.

Distance: from tip of snout to center of cloaca 49.4, 49.2; from center of cloaca to 1st dorsal 36.5, 35.1; to tip of tail 50.6, 50.8; from rear end of 2nd dorsal base to tip of tail 3.0, 2.8.

Interspace between: 1st and 2nd dorsals 0.5, 1.3.

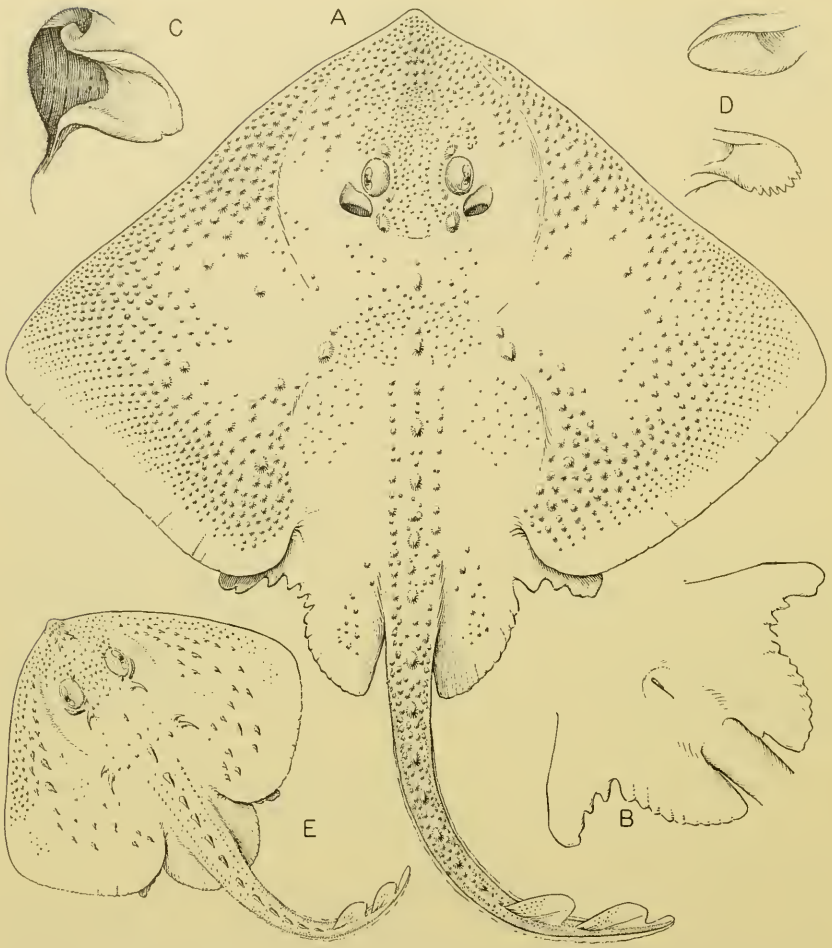


FIGURE 55. *Raja radiata*. *A* Female, 800 mm long, from Massachusetts Bay (Harv. Mus. Comp. Zool., No. 1139). *B* Pelvics of same. *C* Nostril of female, 576 mm long, from Nahant, Massachusetts (Harv. Mus. Comp. Zool., No. 254), about 2.3×. *D* Outer posterior margin of right-hand nostril (above) and of left-hand nostril (below) of male 378 mm long, from Emerald Bank, Nova Scotia, 55 fathoms (Harv. Mus. Comp. Zool., No. 33920), to show variation, about 2.3×. *E* Juvenile female, 127 mm long (Harv. Mus. Comp. Zool., No. 34755).

Disc about 1.3–1.4 times as broad as long; maximum anterior angle in front of spiracles about 110–140°, small specimens averaging more obtuse than large; an-

terior margins slightly concave close behind tip of snout, weakly and evenly convex thence rearward to outer corner of pectorals on newly-hatched specimens but becoming weakly concave with growth at level of eyes and spiracles and about equally so in both sexes to maturity;[107] posterior corners much more broadly rounded than outer corners. Axis of greatest breadth about 70 % of distance back from snout toward axils of pectorals. Tail with narrow lateral folds low down and beginning close behind axils of pelvics; its length from center of cloaca to origin of first dorsal about 80 % as great as distance from center of cloaca to snout in young, 60–70 % at maturity; extreme length of tail from center of cloaca about 1.1–1.2 times as great as distance from cloaca to snout in young, but about 0.9–1.1 times in half-grown specimens and adults.

Upper surface with a median row of 11–19 large conspicuous thorns on radiate bases from nuchal region back nearly to first dorsal fin, usually 1–2 more on adults than on young specimens;[108] 6–9 of these anterior to axils of pectorals and about an equal number along tail, the thorn nearest to the first dorsal sometimes very small; midbelt of back with 1–3 irregular rows of smaller thorns on either side of the midrow, these confined to disc on very small specimens but extending along tail to first dorsal fin on adults, decreasing in size rearward; anterior and median parts of pectorals with scattered thorns, most closely spaced from level of spiracles forward; 2–6 near tip of snout, sometimes one pair conspicuously largest; one prominent thorn close in front of eye, one on inner posterior margin of orbit, and one close to inner end of spiracle; also 2–3 on each shoulder, the most posterior of these usually largest; skin of disc usually without prickles around eyes, behind spiracles, behind shoulders, and on outer posterior parts of pectorals. Skin also without prickles elsewhere between the larger thorns on some specimens but more or less prickly on others, especially on the snout, between the orbits and on the shoulders; skin above eyes either naked or prickly; tail with a thick-set belt of very small prickles low down along either side from axils of pectorals to below dorsals, these prickles being especially conspicuous on small specimens; dorsals prickly; space between dorsals with one small thorn, or none, if the fins are separated; caudal membrane sometimes with a few minute prickles, but usually smooth; pelvics sometimes naked, but more often with central area more or less prickly, sometimes with 1–2 thorns. Sexually maturing females become increasingly thorny over the midzone of the disc in general, on the shoulders, and over the outer anterior parts of the pectorals; they also become increasingly prickly between the thorns. But maturing males lose most of the thorns from the pectorals except along the anterior margins. Alar spines of mature males in 3–5 rows, each row about as long as distance between outer margins of orbits. Lower surface smooth on small specimens, but prickles usually develop with growth on the midzone of the snout about halfway back toward the mouth, along the extreme outer margins of the disc to the level of the spiracles in

107. We have a male 540 mm long with well developed claspers, caught off South Carolina, on which the anterior margin of disc is sharply indented opposite level of spiracles.

108. From the Gulf of Maine, three out of five small specimens, 126–153 mm long, had 12 mid-dorsal thorns, one had 13, and one had 14; among 31 larger specimens, one had 11, two had 12, eleven had 13, nine had 14, four had 15, and four had 16; West Greenland specimens had 13–19 (Jensen, Spol. Zool. Mus. Hauniensis, 9, 1948: 28).

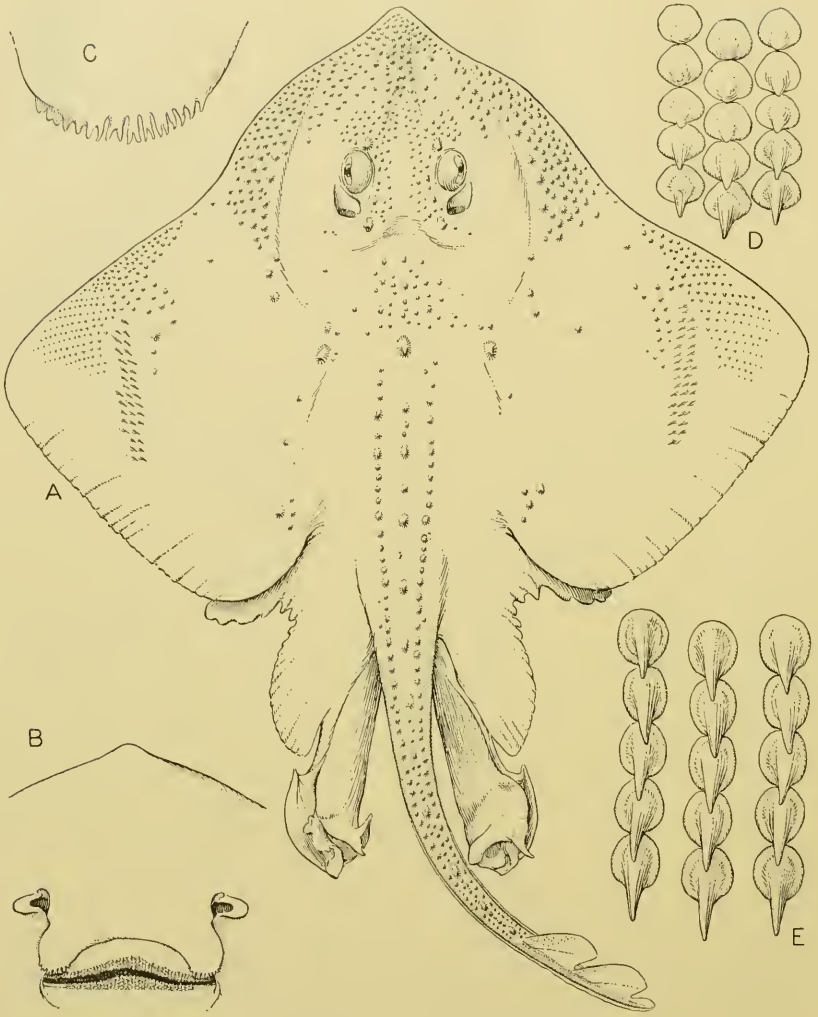


FIGURE 56. *Raja radiata*. *A* Mature male, 530 mm long, from Massachusetts Bay (Harv. Mus. Comp. Zool., No. 249). *B* Mouth and nostril of female, 576 mm long, from Nahant, Massachusetts (Harv. Mus. Comp. Zool., No. 254). *C* Margin of nasal curtain of same, about 2.3×. *D* Upper teeth of female, from Grand Manan Island, New Brunswick (Harv. Mus. Comp. Zool., No. 132), about 4.6×. *E* Upper teeth of mature male, from Ivigtut Fjord, West Greenland (Harv. Mus. Comp. Zool., No. 36557), about 4.6×.

females by maturity, and over the lower surface of the snout as a whole anterior to the nostril in mature males.[109]

Snout in front of orbits about 2.4–2.5 times as long as distance between orbits in adult males, a little longer relatively in adult females; its length in front of mouth about 1.3–1.7 times as long as distance between nostrils. Orbit about 75–100 % as long as distance between orbits in small specimens, relatively a little shorter in large, and about 1.2–1.4 times as long as spiracle. Distance between first gill openings 1.8–2.1 times as long as distance between exposed nostrils, 1.4–1.7 times between fifth gill openings; first gill openings 1.0–1.3 times as long as fifth and about 15–20 % as long as breadth of mouth. Nasal curtain fringed, the expanded posterior (outer) margin of nostril either smooth or coarsely or finely fringed, not always alike on the two sides. Mouth only a little more arched in adult males than in females and young.

Teeth $\frac{36-46}{36-46}$, with round bases and low cusps, worn nearly smooth in oldest rows but conical in youngest, close-set in quincunx in young specimens but teeth more loosely spaced and the series more nearly transverse in older ones; those of adult males only slightly sharper and spaced only a little more widely than in females.

First and second dorsals similar in size and shape, either confluent at base or separated by an interspace up to nearly half as long as base of first dorsal. Caudal membrane posterior to base of second dorsal about 1/4 as long as base of first dorsal subsequent to loss of filamentous embryonic prolongation. Pelvics moderately concave and scalloped from base of excavation rearward; anterior margin about 55–72 % as long as distance from its own origin to rear tip of pelvic in large specimens, about 78–86 % in small of both sexes; anterior lobe broad, including about five radials; outer margin of posterior lobe moderately convex, rear corner narrowly rounded. Claspers of sexually mature male conspicuously robust, extending rearward about 4/5 the distance from axils of pelvics toward first dorsal.

Anterior rays of pectorals extending about 2/3–3/4 of the distance forward from level of front of orbits toward tip of snout.

Color. Upper surface brown, either uniform or partially clouded or spotted with darker; small specimens often spotted more definitely than older ones; sometimes a white spot beside each eye, one on each side opposite the nuchal region, and another on each side on the posterior part of the disc. Lower surface white, sometimes with irregular sooty or brownish blotches.

Remarks. The North American form, *R. scabrata*, has been separated from *R. radiata* of the eastern Atlantic because it is "larger, less rough, and rather more angular" and because the small prickles are more sparsely scattered or absent from considerable areas.[110] But our own examination of the series listed under Study Material (p. 255) has failed to show any consistent differences in any of these respects between those from American, West Greenland, or Norwegian waters.[111]

109. These areas are smooth on a mature male 540 mm long from South Carolina.

110. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 340.

111. Some specimens from Norway that we have seen are densely prickly over the upper surface as a whole, except for the anterior lobes of the pelvics; but another specimen from the same region has only a few scattered prickles,

Size. In American waters, *R. radiata* is hatched at a length of about 100 mm from snout to origin of first dorsal fin. But those of northern European seas, where the egg cases average somewhat smaller (see p. 260), may hatch at a correspondingly smaller size.[112] It may mature through a wide range of sizes. Thus, a male only 21 1/4 inches long (540 mm) was fully mature, whereas another about 33 1/2 inches (845 mm), both seen by us, has the claspers extending only slightly beyond the tips of the pelvics. On another of about the same size as the latter (830 mm, or about 33 in.), the claspers reach nearly halfway along the tail and appear to be fully developed; they are surely so on another of 935 mm. Females as long as 1,020 mm (Nova Scotia) and as short as 450 mm (North Sea and Norway) have been reported as containing eggs. The Icelandic and American stocks tend to grow larger than those of northern Europe or West Greenland. Thus, the maximum recorded length is only 450 mm for the North Sea, about 600 mm for Norwegian waters,[113] and 590 mm for West Greenland;[114] but the maximum size is 990 mm for Iceland,[115] 1,020 mm for the Scotian Banks,[116] about 895 mm (35 1/4 in.) for Georges Bank,[117] 800 mm for Massachusetts Bay, and 935 mm for the offing of New Jersey.

Developmental Stages. The egg cases, flat on one side but strongly convex on the other, are rough with narrow longitudinal ridges. A membrane-like mass of delicate fibrils, matted together, extends along each lateral margin (over the surface as a whole at deposition); each horn terminates in a slender fibril.[118] The cases vary widely in size, probably corresponding to the size of the parent fish. In the North Sea they average about 48 by 34 mm (exclusive of horns), in Trondhjem Fjord 50–65 by 40–48 mm, off West Greenland[119] 45–68 by 26–51 mm, on the outer Nova Scotian Banks 77–90 mm long from mothers 840–1,020 mm long, and in the estuary of the St. Lawrence River (size of parents not recorded) 66–68 mm long.[120] The single egg case recorded from Georges Bank, taken from a fish about 810 mm long (32 in.), measured 76 by 57 mm (3 by 2 1/4 in.).

At hatching the young already resemble their parents so closely (apart from whatever vestiges of the embryonic caudal filament may persist) that their identification presents no difficulty. This is one of the Skates for which monstrosities, such as those

as is often true of the Gulf of Maine specimens. Some from Southwest Greenland and from the Newfoundland Banks are more or less prickly above the eyes and have a few prickles scattered among the thorns, whereas others are smooth above the eyes and between the thorns, as is commonly the case on New England specimens. However, it may develop that there is some geographic variation in the average number of mid-dorsal thorns, for the maximum number seen on any Gulf of Maine specimen has been 16, whereas there are 16 each on two out of six from West Greenland and on two out of three from Norway.

112. An embryo 84 mm long to origin of first dorsal (120 mm long to tip of tail, but with the latter still filamentous) bears a yolk sac of considerable size, but the thorns have not yet been formed though their pattern is already evident. The smallest free-living specimen we have seen, a newly hatched one from Georges Bank which had already lost its caudal filament, was 100 mm long to first dorsal and 126 mm in total length.

113. Smitt, Hist. Scand. Fish., 2nd ed., 1895: 1108.

114. In our Study Material.

115. Saemundsson, Skr. Komm. Havunders. Kbh., 5, 1909: 125.

116. Vladykov, Nat. canad., *63*, 1936: 225.

117. Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 325.

118. For description of egg cases and of early stages in embryonic development, see Nordgaard (K. norske vidensk. Selsk. Skr. [1915], Heft 2 [9], 1916: 24; and Vladykov, Nat. canad., *63*, 1936: 223).

119. Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 30.

120. Vladykov, Nat. canad., *63*, 1936: 225.

described on p. 143, have been reported, with the anterior parts of the pectorals separate from the sides of the head.[121]

Habits. Regarding the diet of *R. radiata* off the American Coast, we only know that several specimens caught by us on Georges Bank in September had been feeding on shrimps, spider crabs, anemones, hydroids, worms, and fishes of undetermined species. In Icelandic waters *R. radiata* is reported as feeding on small crustacea, especially gammarids and spider crabs (*Hyas*), and on small fishes (*Ammodytes*); off Norway they feed on crustacea, fishes, and worms,[122] and off West Greenland on crustacea.

In the western side of the Atlantic *R. radiata* evidently produces young throughout its geographic range, for females containing well formed eggs, or egg cases containing embryos, have been taken all along the coast of West Greenland from Disko Bay (Lat. 69°26′ N) southward, on the southwest slope of the Newfoundland Banks, off the outer coast of Nova Scotia, and on Georges Bank fronting the Gulf of Maine. Also, it appears that this species may deposit its eggs at any time of year in those parts of its range where winter chilling is not too severe, for gravid females, or deposited eggs in various stages of incubation, have been found in January and February in Trondhjem Fjord, Norway; from February to June, and again in October, in the North Sea off Aberdeen, Scotland; from June to August around Iceland;[123] in the summer off West Greenland; in July on the southwest slope of the Grand Banks of Newfoundland (see p. 263); in April, June, July, and September off Nova Scotia; and in September on Georges Bank. The period of incubation is not known.

In general *R. radiata* is restricted to depths greater than about 10 fathoms even in the northern part of its range. In the Gulf of St. Lawrence, for example, it is described as having been caught "at considerable depths" only.[124] Recorded captures from the Newfoundland and Scotian Banks have been 20 fathoms and deeper; in the Bay of Fundy-Passamaquoddy region it is taken only in water deeper than 10 fathoms; of the many specimens taken by us in the Gulf of Maine, the shoalest was at 14 fathoms.[125] At the other extreme of its depth range, it is taken regularly down to 100 fathoms throughout its latitudinal range (many as deep as 120 fath.), while it has been trawled between 160 and 336 fathoms at numerous localities along the upper part of the continental slope in the offing of southern New England; down to 218 fathoms south of Newfoundland; to 250 fathoms in Trondhjem Fjord; to 330 fathoms off West Greenland; and to 459 fathoms near Spitzbergen. There is nothing in the available record to suggest that this species carries out any regular seasonal migrations in American waters, whether inshore and offshore or north and south.

The Starry Skate is more catholic in respect to its choice of bottom habitat than are some other Skates, for while it is most plentiful on good fishing grounds of sand

121. Reported for a specimen off Iceland by Saemundsson (Skr. Komm. Havunders. Kbh., 5, 1909: 126).
122. Saemundsson, Skr. Komm. Havunders. Kbh., 5, 1909: 126; Smitt, Hist. Scand. Fish., 2nd ed., 1895: 1110.
123. Saemundsson, Skr. Komm. Havunders. Kbh., 5, 1909: 126.
124. Cox, Contr. Canad. Biol. (1918–1920), 1921: 109.
125. The report of it being taken in fish traps at Woods Hole (Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31*, 1913: 738) lacks supporting evidence as to identity.

and broken shells, sand and gravel, or gravel and pebbles, we have also taken it at many stations in the Gulf of Maine where soft mud floors the deeper troughs. It does not occur regularly at any locality where the bottom temperature rises above 9–10° C (48–50° F) for more than short intervals, though it can survive brief exposure to temperatures much higher than those to which it is subjected in any part of its range.[126] At the other extreme, many have been taken in Newfoundland waters where the temperatures go down to 1.1° C (34° F), or nearly as low as temperatures are in the open sea off the eastern American seaboard. Nor does it show any apparent preference for either the upper half of its thermal range or for the lower. However, the polar temperature of the ice-chilled Labrador Current may be responsible for its scarcity along the northeastern coast of Newfoundland north of the offing of Conception Bay and along Atlantic Labrador as contrasted with its abundance along southwestern Greenland, where the temperature of the bottom water at depths where it occurs are upwards of 2–3° C (36–37° F) for the most part during late summer and early autumn.[127]

R. radiata is seldom (if ever) encountered in water less saline than 31.2–31.5 ‰ (shoaler parts of Gulf of St. Lawrence; also Passamaquoddy Bay); the recorded maximum for it is about 35.3 ‰, and the great majority of the American population throughout its latitudinal range exists in salinities ranging from about 32–34.5 ‰.

Numerical Abundance. In September 1929, 37 trawl hauls on Georges Bank yielded a catch of 325 *R. radiata*, and trawling on the Newfoundland Banks yielded a maximum catch of 54 per hour. As further evidence of its abundance we may quote catches of 12 *R. radiata* in 30 minutes in the western side of the Gulf of Maine with a beam trawl that was only eight feet across at the mouth, and of 1–100 specimens in 26 trawl hauls between Mt. Desert Island and Massachusetts Bay.[128] Off the coast of southern New England, 21 were taken in 17 half-hour trawl hauls in 71–260 fathoms, but none were taken in 46 hauls made in 22–69 fathoms on the same cruise.[129]

Relation to Man. No commercial use is made of this particular Skate in American waters, but a few are dried and salted in Iceland.[130]

Range. Continental waters in both sides of the northern North Atlantic in boreal and subarctic latitudes. On the east, from the White and Barents seas, Bear Island, Spitzbergen, Iceland, Norway, and the western part of the Baltic to the Dutch Coast, and reported doubtfully from Belgium and the Bay of Biscay;[131] in the west from Labra-

126. The lethal upper temperature for it is 26.5–26.9° C, according to experiments by Huntsman and Sparks (Contr. Canad. Biol., N. S. *2*, 1924: 102).

127. The bottom water at depths of 25–50 fathoms is colder than 0° C (32° F) for the most part from July into September along northeastern Newfoundland and Atlantic Labrador. See Iselin (Proc. Amer. Acad. Arts Sci., *66*, 1930: 3–25) and Smith, Soule and Mosby (Sci. Res. Marion-Gen. Greene Exped., U. S. Cst. Guard, *2*, 1937: fig. 56) for bottom temperatures along northeastern Newfoundland and Atlantic Labrador; for the Grand Banks region, see tables and charts in Rep. Newfoundland Fish. Res. Comm. (*1* [4], 1932; *2* [1], 1933; *2* [2], 1934; *2* [3], 1935); for the West Greenland fishing grounds, see Beaugé (Rev. Trav. Off. Sci. Techn. Pêches marit., *4* [1], 1931: 111–112; *5* [1], 1932: 59–68; *6* [1], 1933: 97–100) and Smith, Soule and Mosby (Sci. Res. Marion-Gen. Greene Exped., U. S. Cst. Guard, *2*, 1937: figs. 13, 15, 20).

128. July–November, 1927–1930. 129. ALBATROSS III, May 11–18, 1950, between Long. 67°10′ and 72°20′ W.

130. Saemundsson, Skr. Komm.! Havunders. Kbh., *5*, 1909: 126.

131. For a recent summary (with references) of the distribution of *R. radiata* in the eastern Atlantic and tributary seas, see Clark (Rep. Fish. Bd. Scot. [1926], 1, 1926: 29).

dor, West Greenland, Hudson Bay, Grand Banks region, and Gulf of St. Lawrence to South Carolina.

Occurrence in the Western North Atlantic. R. radiata is common in depths of 30–330 fathoms all along the west coast of Greenland from Disko Bay (about Lat. 69°26′ N) to the vicinity of Cape Farewell, both offshore and in the fjords; many have also been taken on Fylla Bank and in the central part of Davis Strait.[132] Knowledge of it off the coasts of subarctic America is confined to one report for the southeastern part of Hudson Bay,[133] a second from Lake Melville, Labrador[134] and another from off the outer coast of Labrador in the offing of Hamilton Inlet.[135] However, it is common on the fishing grounds all around the marginal belt of the Grand Banks area as a whole (southward from the latitude of Conception Bay) and at the mouths of the larger bays (Placentia, St. Mary) on the southern coast of Newfoundland. It is widespread throughout the southern side of the Gulf of St. Lawrence as far inward as the estuary of the St. Lawrence River, and doubtless it is present along the eastern (Newfoundland) side of the Gulf as well, to judge from its reported occurrence in the southern side of the Strait of Belle Isle. It occurs also along the outer Nova Scotian shelf and fishing banks, throughout the Gulf of Maine, and over Georges Bank. However, most of the positive records for it westward from about the longitude of Cape Cod (70° W) have been from a narrow belt that extends along the upper part of the continental slope between the 150 and 300 fathom contours, about as far south as the so-called Hudson Trough (about Long. 72° W) that cuts across the shelf off New York. But we have seen one specimen taken 25 miles off the eastern end of Long Island, New York at a depth of only 32 fathoms; and we have another that was caught off Charleston, South Carolina, in 74 fathoms.[136]

Synonyms and References:

Raja[137] *radiata* Donovan, Nat. Hist. Brit. Fish., *5*, 1807: pl. 114 (ill., Gt. Britain); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 61 (listed, Atlant. Coast N. Amer.); Garman, Proc. Boston Soc. nat. Hist. *17*, 1874: 178 (descr., cf. other species, Mass.); Goode and Bean, Bull. Essex Inst., *11*, 1879: 28 (Mass.); Jones, List Fish. Nova Scotia, 1879: 11 (listed, Nova Scotia); Bean, Proc. U. S. nat. Mus., *3*, 1880: 115 (Nova Scotia and Mass. locals.); Verrill, Amer. J. Sci., (3) *22*, 1881: 297 (small nos. 160–241 fath. off Gay Head); Jones, Proc. N. S. Inst. Sci., *5* (1), 1883: 97 (same as Jones, 1879); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 41 (descr.); Bean, Rep. U. S. Comm. Fish. (1882), 1884: 343 (listed, Woods Hole); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed, north. U. S., Europe); Goode and Bean, Smithson. Contr. Knowl., *30*, *31*, 1895; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 25, pl. 9, fig. 27 (ill., depth off New England Coast); Cox, Bull. nat. Hist. Soc. N. Brunsw., 13, 1896: 75 (Bay of Fundy); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 69 (descr., N. Atlant., Amer., Europe); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, N. Atlant., Amer., Europe); Gar-

132. For a general survey of its occurrence in West Greenland waters, see Jensen (Spol. Zool. Mus. Hauniensis, *9*, 1948: 28).

133. Vladykov, Contr. Canad. Biol., N. S. *8*, 1933: 17.

134. Reported by David C. Nutt and identified by us from a photograph. Caught by the BLUE DOLPHIN in 20 fathoms, with otter trawl, July 25, 1950. Length about 275 mm. For additional Labrador records, just published, see Backus (Copeia, 1951: 289).

135. Rep. Newfoundland Fish. Res. Comm., *2* (1), 1933: 125; Lat. 54°15′ N, Long. 55°05′ W.

136. Taken by the ALBATROSS III February 1, 1950 in Lat. 33°10′ N, Long. 77°25′ W (Harv. Mus. Comp. Zool., No. 37061).

137. Also spelled *Raia.*

man, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (depth, range); Smith, Bull. U. S. Fish Comm., *17*, 1898: 89 (listed, Woods Hole); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 12 (New England locals., but ref. for New London (?), Conn. based on *R. americana* DeKay 1842, which equals *R. eglanteria* Bosc 1802); Roule, Bull. Inst. océanogr. Monaco, 243, 1912: 20 (depth, Grand Banks); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Halkett, Check List Fish. Canad., 1913: 42 (listed, Maritime Provinces and southward); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31*, 1913: 738 (listed, Woods Hole); Bigelow, Bull. Mus. comp. Zool. Harv., *58*, 1914: 100, 111 (depth, Gulf of Maine); Huntsman, Trans. roy. Soc. Canad., (3) *12* (4–5), 1918: 63 (depth, temp., Gulf St. Lawrence); Cox, Contr. Canad. Biol. (1918–1920), 1921: 109 (depth, S. side Gulf St. Lawrence); Huntsman, Contr. Canad. Biol. (1921), 3, 1922: 6, 9 (Passamaquoddy Bay and Bay of Fundy); Huntsman and Sparks, Contr. Canad. Biol., N. S. *2*, 1924: 102 (upper lethal temp.); Battle, Trans. roy. Soc. Canad., Sect. 5, (3) *20* (1), 1926: 127, 132 (effects of high temp.); Huntsman, Trans. roy. Soc. Canad., Sect. 5 (3) *20* (2), 1926: 203 (upper lethal temp.); Nichols and Breder, Zoologica N. Y., *9*, 1927: 24 (ill., old Woods Hole record); Vladykov, Contr. Canad. Biol., N. S. *8*, 1933: 17 (SE shore, Hudson Bay); Nat. canad., *63*, 1936: 123, 125 (meas., photos egg cases, estuary St. Lawrence R.; *R. radiata* considered distinct from *R. scabrata*); Contrib. 17, Dept. Pêch. Quebec, 1946: 26 (in stomach of White Whale, estuary St. Lawrence R.); Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 27 (descr., Greenland).

Raja clavata or *R. radiata* Storer, Rep. Fish. Rept. Birds Mass., 1839: 201 (Mass.); Boston J. nat. Hist., *2*, 1839: 556 (same as Storer, 1839).

Raia laevis (in part) Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1867: 242, pl. 39, fig. 2; also Fishes Mass., 1867: 266, pl. 39, fig. 2 (ill., but descr. partly based on *R. laevis*, Mass. Bay).

Raia scabrata Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 340, pl. 21, fig. 2, pl. 44, figs. 1–3 (descr., ills., Mass. Bay, but pl. 21, fig. 1, labelled *R. scabrata*, is actually *R. ocellata*); Jordan, Copeia, 49, 1917: 87 (*scabrata* replaces *radiata* for American form); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 62 (descr., ill., Gulf of Maine); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 30 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 17 (diagn.); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (Mass. Bay, considered distinct from European *R. radiata*); Lutz, Amer. J. Physiol., 94, 1930: 135 (effects of adrenalin); Marshall, Contr. Canad. Biol., N. S. 7 (1–7), 1931: 19 (heart physiol.); Schroeder, Bull. Boston Soc. nat. Hist., *58*, 1931: 3 (nos., depth, Gulf of Maine and Georges Bank); Anon., Rep. Newfoundland Fish. Res. Comm., *1* (4), 1932: 117 (Newfoundland Coast, Newfoundland and Nova Scotian banks); Rep. Newfoundland Fish. Res. Comm., *2* (1), 1933: 125 (depth, temp., off Nova Scotia, Grand Banks, and outer Labrador); Préfontaine, Trans. roy. Soc. Canad., (3) *27* (5), 1933: 257 (depth, estuary of St. Lawrence R.); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 23 (descr., ill., Hudson Bay to Woods Hole); Anon., Rep. Newfoundland Fish. Res. Comm. (1933), *2* (2), 1934: 115 (Newfoundland, east. Nova Scotian Banks and Gulf of St. Lawrence); Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51 (off Nova Scotia); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324 (descr., size, female with eggs, egg cases, food, nos., Georges Bank); Vladykov, Nat. canad., *63*, 1936: 223 (descr., size, photos egg cases, depth, temp., season, off Nova Scotia); Norman, Discovery Rep., *16*, 1937: 16, footnote (*R. scabrata* Garman 1913 probably ident. with European *R. radiata*); Bigelow and Schroeder, Biol. Bull. Woods Hole, *76*, 1939: 309 (deep basins, Gulf of Maine).

Doubtful References:

Raja radiata Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 470 (egg cases with embryos "perhaps" this species, New Jersey).

Raja scabrata Fowler, Proc. biol. Soc. Wash., *33*, 1920: 145 (same as *R. radiata* Fowler 1910).

Raja senta Garman 1885

Figures 57, 58

Study Material. Sixty specimens, 83 mm (newly hatched) to 547 mm long, from: Emerald Bank off Halifax, Nova Scotia; St. Andrews, New Brunswick; various localities

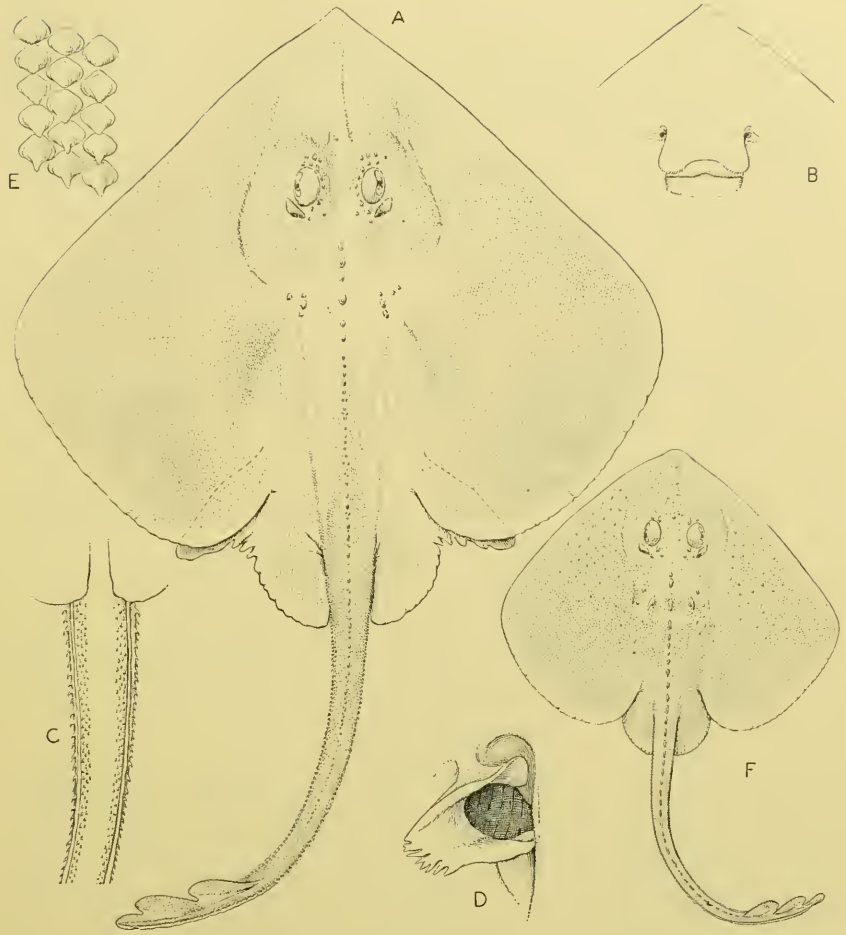


FIGURE 57. *Raja senta*. *A* Female, 424 mm long, from Emerald Bank, Nova Scotia (Harv. Mus. Comp. Zool., No. 33919). *B* Lower surface of anterior part of head of same, about 0.4×. *C* Lower side of anterior part of tail of same, about 0.6×. *D* Right-hand nostril of same, about 3.3×. *E* Upper teeth of same, 2nd–6th rows, about 6.5×. *F* Juvenile female, 159 mm long, from Cashes Ledge, Gulf of Maine, Lat. 42°53′ N, Long. 68°58′ W (Harv. Mus. Comp. Zool., No. 34768).

in the Gulf of Maine; the offings of southern New England and New Jersey; also one specimen from off Charleston, South Carolina; all in the collections of the Harvard Museum of Comparative Zoology and the U. S. National Museum.

Distinctive Characters. R. senta is unique among hard-nosed Skates (*Raja*) of the North and South Atlantic from the time it has grown to one-fourth its mature size[138] in that the thorns on the tail dwindle in size rearward until those along the posterior half to third are no longer distinguishable from the small prickles with which the tail is generally clothed. Newly hatched specimens, in which this character is not yet established, are separable from other hard-nosed Skates of the western North Atlantic by the color pattern of the tail, which has two pale crossbars, each outlined anteriorly and posteriorly by a dark band or blotch. They are set apart from the barred-tailed species of *Breviraja* by the long rostral cartilage (reaching to tip of snout).

Description. Proportional dimensions in per cent of total length. Female, 424 mm, and male, 520 mm, from Emerald Bank, off Nova Scotia (Harv. Mus. Comp. Zool., No. 33919).

Disc: extreme breadth 62.0, 63.5; length 51.2, 50.5.
Snout length: in front of orbits 15.1, 12.5; in front of mouth 15.3, 12.8.
Orbits: horizontal diameter 4.2, 3.7; distance between 3.8, 4.0.
Spiracles: length 2.6, 2.5; distance between 6.6, 7.1.
Mouth: breadth 7.3, 8.1.
Nostrils: distance between inner ends 7.3, 7.1.
Gill openings: lengths, 1st 1.9, 1.8; 3rd 1.8, 1.8; 5th 1.2, 1.3; distance between inner ends, 1st 13.7, 13.7; 5th 7.5, 6.0.
First dorsal fin: vertical height 2.2, 2.6; length of base 5.4, 5.2.
Second dorsal fin: vertical height 2.4, 2.5; length of base 5.0, 6.1.
Pelvics: anterior margin 14.6, 13.6.
Distance: from tip of snout to center of cloaca 47.5, 46.5; from center of cloaca to 1st dorsal 38.7, 39.0; to tip of tail 52.5, 53.5; from rear end of 2nd dorsal base to tip of tail 3.3, 3.1.
Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc about 1.2–1.3 times as broad as long; maximum anterior angle in front of spiracles about 110°; anterior margins nearly straight rearward from tip of snout in adult females and in young of both sexes, but bulging moderately in front of level of eyes in adult males; outer and posterior corners broadly rounded, posterior margins strongly convex. Axis of greatest breadth about 70 % of distance back from tip of snout toward axils of pectorals. Tail with lateral folds confined to posterior two-thirds and so narrow that they are likely to be overlooked; its length from center of cloaca to first dorsal about as great as distance from center of cloaca to tip of snout in small specimens, decreasing in relative length with growth to about 80–90 % as great in adults; extreme length of tail from center of cloaca about 1.1 times as great as length from cloaca to snout in one-third-grown specimens and larger.

Small specimens closely and uniformly prickly above on entire disc, on inner parts of pelvics and on tail; 1–2 large thorns in front of orbit and as many behind it; 4–5

138. It is also distinguishable from hard-nosed Skates of the Pacific Coast of America by the same character.

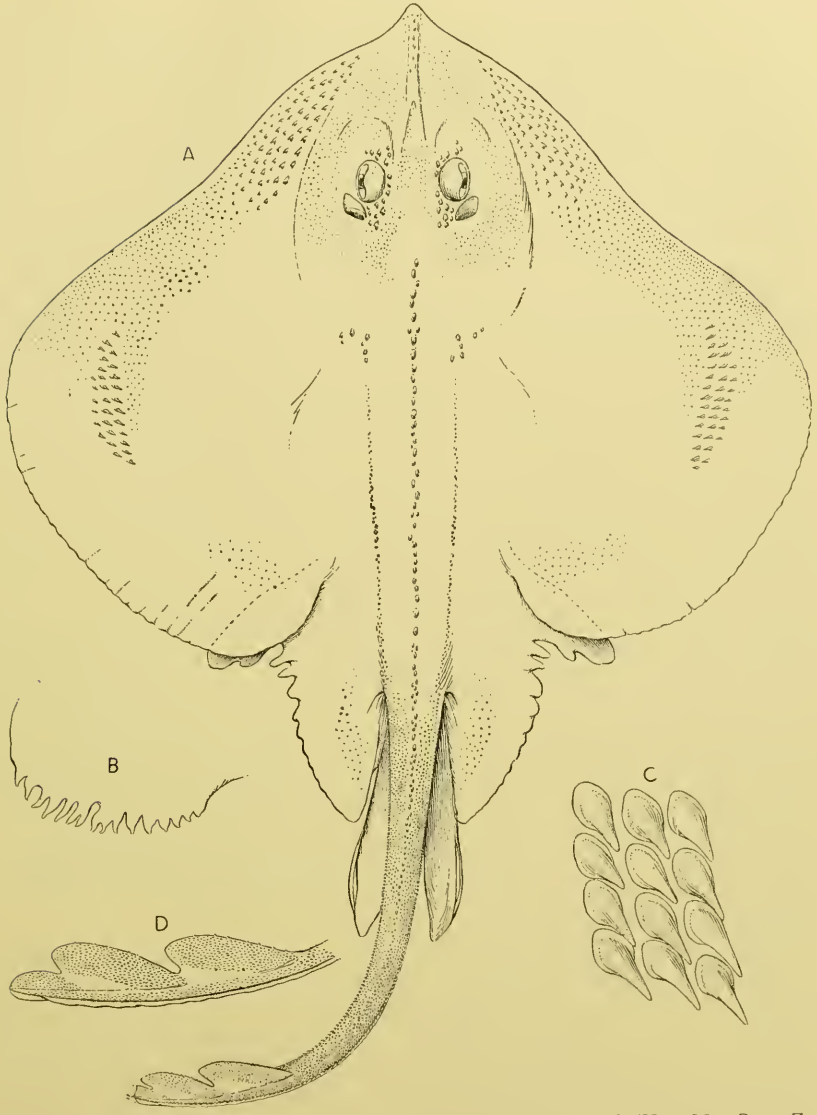


FIGURE 58. *Raja senta*. *A* Male, 520 mm long, from Emerald Bank, Nova Scotia (Harv. Mus. Comp. Zool., No. 33919). *B* Margin of right-hand nasal curtain of same, about 3.7×. *C* Upper teeth of same, about 7.4×. *D* Side view of posterior part of tail of female pictured in Fig. 57, about 0.9×.

around inner margin of orbit; one on each shoulder; a row of thorns along midline of back, 10–12 large ones anterior to axils of pelvics, followed by successively smaller ones along tail until no longer distinguishable from the prickles a short distance anterior to first dorsal. Large specimens of both sexes with 2–3 preocular thorns, 1–2 postoculars, about eight along inner margin of orbit, 3–5 on each shoulder, and 16 or more larger and smaller thorns spaced irregularly along midline of disc; tail usually with 20–30 thorns in midrow along anterior one-half to two-thirds, these of different sizes, progressively smaller rearward; each side of tail low down with 1–3 irregular rows of thorns along anterior part, grading down to minute prickles above, below, and rearward; posterior one-third to one-half of tail without large thorns—the most distinctive character of the species. Females remain prickly on the upper surface as a whole to maturity (in addition to thorns), densely so on the tail, but irregular bare areas develop in the general region of the shoulders and around the outer parts of the pelvics. Maturing males lose the prickles from the central portion of the disc as a whole, but they develop a few medium-sized thorns on the anterior part of the rostral ridge; also smaller thorns over the anterior parts of the pectorals (only prickly in females) and large thorns over a roughly triangular area on either side abreast of the eye and anterior to it. Alar spines of mature males in two rows on either side, 13–14 in each row. Lower surface of disc smooth in small specimens, but prickles develop later along a narrow marginal band from snout back about halfway toward level of nostrils; lower surface of tail either densely prickly throughout on young of both sexes and on females to maturity, or at most with a narrow naked median band, but becoming generally smooth in males by maturity.

Snout in front of orbits about 3.1–4.0 times as long as distance between orbits, its length in front of mouth about 1.8–2.1 times as long as distance between exposed nostrils. Orbit about 1.5 times as long as spiracle. Distance between first gill openings 1.9 times as long as distance between exposed nostrils, 0.9–1.0 times between fifth gill openings; first gill openings 1.4–1.6 times as long as fifth and about 26 % as long as breadth of mouth. Nasal curtain as well as expanded posterior (outer) margin of nostril fringed. Mouth moderately arched in adult females, more strongly so in adult males.

Teeth $\frac{38-40}{36-38}$, evenly rounded in anterior rows but with faintly indicated cusps in posterior rows and closely crowded in quincunx in young specimens and in females to maturity; but teeth of mature males with high, recurved, sharp-pointed cusp and spaced more loosely in transverse series.

First and second dorsals similar in size and shape, confluent at base. Caudal membrane posterior to base of second dorsal about half as long as base of first dorsal. Pelvics deeply concave outwardly and strongly scalloped around the indentation; anterior margin about 75–85 % as long as distance from its own origin to rear tip of pelvic in half-grown and large specimens, as much as 90 % in young; anterior lobe narrow, including only two radial cartilages besides the first and stoutest; posterior lobe with moderately convex outer margin and well rounded posterior corner. Claspers of mature male extend back about $\frac{1}{2}$ to $\frac{3}{5}$ the distance from axils of pelvics toward first dorsal.

Anterior rays of pectorals extend forward about 80–85 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface pale brown with numerous obscure darker spots, sometimes with irregular pale markings; tail similar to disc in adults, but newly hatched specimens with two transverse pale bars, each outlined by a dark crossbar in front of it and another behind. These bars are lost with growth, so that specimens of 180–200 mm may show either one or two; specimens of 280–300 mm have either one or none. Lower surface of disc and pelvics either plain white or with a few small dusky spots on outer parts of pectorals, or one at tip of snout; the tail either white below, variously dark-blotched, or uniformly dark along the posterior third.

Size. The three smallest specimens we have seen—apparently hatched not long previously but with the filamentous tip of the caudal already lost—were 83–87 mm long. A male of 515 mm is shown to be mature or nearly so by the size of its claspers. The maximum length reported is 24 inches (610 mm).

Developmental Stages. Egg cases, probably of this species, are dark brown or almost black, squarish and smooth-shelled, 56–59 mm long (exclusive of horns) by 35–39 mm broad, one side nearly flat but the other strongly convex. The horns are thick and at least as long as the capsule (tips broken off in all specimens seen).[139]

Habits. Nothing is known of the diet of this Skate. It has been taken, apparently with equal regularity, on the soft mud and clay bottoms of the deeper troughs and basins as well as on the sand, sand and shells, gravel, and pebbles of the offshore fishing banks. Egg cases, some empty and others containing embryos, apparently of this species,[140] have been trawled in the estuary of the St. Lawrence River at 150–300 meters (82–164 fath.) in July and August. The fact that an empty egg capsule has been found on the shore near Halifax, Nova Scotia, makes it probable that *R. senta* breeds throughout its geographic range.

The shoalest captures of *R. senta* that have been definitely recorded were at 25 and 44 fathoms in the southwestern part of the Gulf of Maine, off Cape Cod, and the great majority of records range from 50–250 fathoms off southern New England[141] and 210 fathoms off New Jersey to 478 fathoms (one specimen) off South Carolina. It is recorded from 82–178 fathoms in the Gulf of St. Lawrence, and from 50–100 fathoms on LaHave and Emerald banks off outer Nova Scotia.

The lowest temperature from which *R. senta* has been definitely recorded, in the estuary of the St. Lawrence River, was about 2–4° C (36–39° F). The local populations may also be exposed to temperatures equally low on the banks off southeastern Nova Scotia into the summer when the ice-cold outdraught from the Gulf of St. Lawrence extends coastwise in that direction;[142] similar exposure to cold waters is likely on Georges

139. For description and photographs, see Vladykov (Nat. canad., *63*, 1936: 220–221).

140. Separable by their small size from those of *R. radiata*, the only other Skate that is known to occur in the region where they were collected.

141. *R. senta* was taken in eight hauls deeper than 100 fathoms by ALBATROSS III between Long. 67°10′ and 72°20′ W, but not in 55 hauls shoaler than that.

142. The bottom temperature on July 29, 1914 was about 2.8° C (37° F) on La Have Bank at 95 fathoms, but 5.6° C (42° F) at 80 fathoms on Emerald Bank off Halifax a week later.

Bank during March when the water is coldest, and likewise in the inner parts of the Gulf of Maine, if any *R. senta* remain there in shallow water of 30–40 fathoms through the late winter and spring.

The fact that *R. senta* has never been reported from water colder than about 2° C (36° F) suggests that low temperature is the barrier that bars it from regularly populating the more easterly sections of the Nova Scotian (Banquereau) or the Newfoundland banks, for these bottoms are flooded yearly with water as cold as 0° C (or even a little colder) at seasons when the icy outflow from the Gulf of St. Lawrence (in the first case) or the southerly expansion of the Labrador Current (in the second) is at its maximum. At the other extreme, some of the specimens that have been taken along the continental edge off New England and farther south may have been from water about as warm as 11° C (52° F); however, most of them have been taken from water with temperatures between about 6° C (42 or 43° F) and about 9–10° C (49 or 50° F).[143]

Generally *R. senta* has been taken from water at least as saline as 32.6 ‰, most of them from water with salinities higher than 32.8 ‰; undoubtedly specimens along the continental edge live in salinities as high as 34.7 ‰ and probably as high as 35.0–35.4 ‰. There is nothing in the available records to suggest that *R. senta* carries out any regular seasonal migrations.

Numerical Abundance. Most of the records for this particular Skate report the capture of odd individuals only. However, 57 specimens of *R. senta*, out of a total catch of 495 Skates, were taken in 37 trawl hauls on Georges Bank in September 1929, thus giving an average of one to two per haul and indicating a population density similar to that of *R. ocellata* (about two per haul) or *R. laevis* although much smaller than that of *R. radiata* (about eight to nine per haul). Off southern New England and New Jersey, 13 *R. senta* out of a total catch of 77 Skates were taken in eight trawl hauls deeper than 100 fathoms (about one to two per haul).[144]

Range. Atlantic shelf of North America from the latitude of Charleston, South Carolina to the Nova Scotian Banks and Gulf of St. Lawrence; as a stray to the southern part of the Newfoundland Bank.

Occurrence in the Western North Atlantic. Raja senta, once considered a rare species, is now known to occur generally in water of sufficient depth throughout the western side of the Gulf of Maine[145] and along the Nova Scotian side of the Bay of Fundy; this distribution suggests that it will prove as widespread at appropriate depths in the eastern side of the Gulf as it is on Georges Bank. It is known also from the southeast slope of Browns Bank,[146] from LaHave Bank off southeastern Nova Scotia, and from Emerald Bank off Halifax, as well as from the estuary of the St. Lawrence River. It has been

143. To judge from the depths and localities of capture; one specimen from the offing of South Carolina was taken in water of 4° C (39.3° F).

144. By Albatross III between Long. 67°10′ and 72°20′ W, May 11–18, 1950.

145. We have taken it on several occasions in the trough west of Jeffreys Ledge, in the west central part of the Gulf near Cashes Ledge, and at three stations east and southeast from Cape Cod; it has been reported from the Bay of Fundy and off Provincetown at the tip of the Cape.

146. Trawled by Caryn of the Woods Hole Oceanographic Institution, June 18, 1949, at Lat. 42°18′ N, Long. 65°01′ W, in 380–420 fathoms.

reported doubtfully from the northern side of the inner part of the Gulf of St. Lawrence, but it has never been reported from the Nova Scotian shelf east of the offing of Halifax, and it is so rare on the Newfoundland Banks that only a single specimen was taken among the many Skates of other kinds during the trawling experiments of the Newfoundland Fisheries Research Committee during the years 1931–1934.[147] To the westward and southward it occurs regularly, if in small numbers (p. 270), along the upper part of the continental slope in the offing of southern New England, of New York, and of New Jersey[148] within the appropriate depth-zone. One has also been taken at the edge of the continental shelf off northern Virginia,[149] one off Chesapeake Bay[150] at 104 fathoms, and one off Charleston, South Carolina, in 478 fathoms.[151]

Synonyms and References:

Raja[152] *senta* Garman, Proc. U. S. nat. Mus., *8*, 1885: 43 (descr., Provincetown, Mass., and LaHave Bank, Nova Scotia); Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 508; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 508 (LaHave Bank, by ref. to Garman, 1885); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 71 (descr., Newfoundland Banks to C. Cod); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed, Newfoundland Banks to C. Cod); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (depth, local.); Schmitt, Monogr. d'Anticosti, 1904: 283 (doubtful rep. N. shore Gulf of St. Lawrence near Anticosti); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 12 (C. Cod Bay by ref. to Garman, 1885); Proc. Portland Soc. nat. Hist., *2*, 1909: 207 (Labrador [?] by ref. to Schmitt, 1904); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 328, pl. 25, fig. 1 (descr., ill., off New England); Halkett, Check List Fish. Canad., 1913: 42 (listed, Labrador [?], Newfoundland Banks to C. Cod); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40*, 1925: 65 (descr., ill., old records); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 31 (ill., Newfoundland to C. Cod); Jordan, Manual Vert. Anim. NE U. S., 1929: 16 (diagn.); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 25 (listed, Newfoundland Banks to C. Cod); Schroeder, Bull. Boston Soc. nat. Hist., 58, 1931: 2 (depth, temp., season, nos., Gulf of Maine and Georges Bank); Préfontaine, Trans. roy. Soc. Canad., Sect. 5 (3) *27*, 1933: 257 (depth, type of bottom, estuary of St. Lawrence R.); Anon., Rep. Newfoundland Fish. Res. Comm. (1933), *2* (2), 1934: 215 (listed, SW. part of Newfoundland Bank); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 33 (descr., LaHave Bank, Gulf of Maine); Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 51 (depth, LaHave and Emerald banks); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 324, 325 (Gulf of Maine locals., depths); Vladykov, Nat. canad., *63*, 1936: 220, 221 (egg cases, season, depth, estuary of St. Lawrence R. and Bay of Fundy); Bigelow and Schroeder, Biol. Bull. Woods Hole, *76*, 1939: 309 (Gulf of Maine); Vladykov, Contrib. 17, Dept. Pêch. Quebec, 1946: 26 (in stomachs of White Whale, estuary St. Lawrence R.).

Raja species Vladykov and Tremblay, Nat. canad., *62*, 1935: 79 (apparently same specimens rep. by Vladykov, 1936).

Raja spinicauda Jensen 1914

Figure 59

Study Material. Male, 1,236 mm long, nearing sexual maturity, taken off Bonavista Bay on the east coast of Newfoundland at Lat. 48°47′ N, Long. 52°47′ W, from be-

147. Earlier characterizations of it as ranging to the Newfoundland Banks appear to reflect a failure to realize that LaHave Bank (one of the type localities of the species) actually lies off southeastern Nova Scotia.

148. Taken by CARYN in three hauls near Lat. 39°55′ N, Long. 70°40′ W, June and October 1948; in five hauls by ALBATROSS III between Long. 67°10′ and 72°20′ W in the 100–240 fathom zone, May 1950; also one specimen from off New York, in U. S. National Museum; and other specimens seen from offshore trawling stations.

149. Lat. 37°36′ N, Long. 74°15′ W.

150. Lat. 37°03′ N, Long. 74°31′ W.

151. ALBATROSS Sta. 2677, Lat. 32°39′ N, Long. 76°50′ W.

152. Also spelled *Raia*.

tween 91 and 127 fathoms and at a temperature between 0.65 and −1.5° C, in collection of Newfoundland Department of Natural Resources. Also two egg-cases, apparently of this species (p. 275), one with embryo from Banquereau Bank off Nova Scotia, Lat. 44°15′ N, Long. 58°03′ W (source unknown), the other empty, from the continental slope off southwestern Georges Bank, Lat. 39°53′ N, Long. 69°00′ W, from between 260 and 350 fathoms, trawled by the research vessel CARYN of the Woods Hole Oceanographic Institution, September 11, 1949.

Distinctive Characters. Although the upper surface of its disc and tail are more or less prickly (see p. 274), *R. spinicauda* is set apart from all other members of its genus in the western North Atlantic (Greenland to the Amazon) by the fact that its only large thorns are in a single row of 21–26 extending from the level of the axils of the pelvics rearward along the midline of the tail. In these respects it falls closest to *R. laevis*. However, adult specimens of the two species are easily separable, for the tail of *R. spinicauda* bears only the single median row of thorns whereas that of *R. laevis* bears three rows, and while the mucous pores on the lower surface of *R. laevis* are marked with black pigment dots or streaks, those of *R. spinicauda* are not so marked.

Description. Proportional dimensions in per cent of total length. Male, 1,236 mm, from Lat. 48°47′ N, Long. 52°47′ W (specimen from Newfoundland Department Natural Resources).

Disc: extreme breadth 68.0; length 56.6.
Snout length: in front of orbits 17.8; in front of mouth 17.8.
Orbits: horizontal diameter 2.8; distance between 4.9.
Spiracles: length 3.0; distance between 7.3.
Mouth: breadth 8.1.
Nostrils: distance between inner ends 7.4.
Gill openings: lengths, 1st 1.4; 3rd 1.5; 5th 1.1; distance between inner ends, 1st 15.7; 5th 12.4.
First dorsal fin: vertical height 2.0; length of base 3.3.
Second dorsal fin: vertical height 2.0; length of base 3.0.
Pelvics: anterior margin 8.6.
Distance: from tip of snout to center of cloaca 52.7; from center of cloaca to 1st dorsal 37.1; to tip of tail 47.3; from rear end of 2nd dorsal base to tip of tail 2.9.
Interspace between: 1st and 2nd dorsals 1.2.

Disc about 1.2 times as broad as long; maximum anterior angle in front of spiracles about 95°; tip of snout subangular or slightly blunted; anterior outlines nearly straight rearward to level of spiracles, then bulging a little outwardly and following a sinuous outline that is weakly concave and next weakly convex toward outer corners; outer corners rather abruptly rounded, posterior corners much more broadly so; posterior margins weakly convex. Tail with narrow lateral folds extending nearly its entire length, at line of transition from rounded upper surface to flat lower surface; its length from

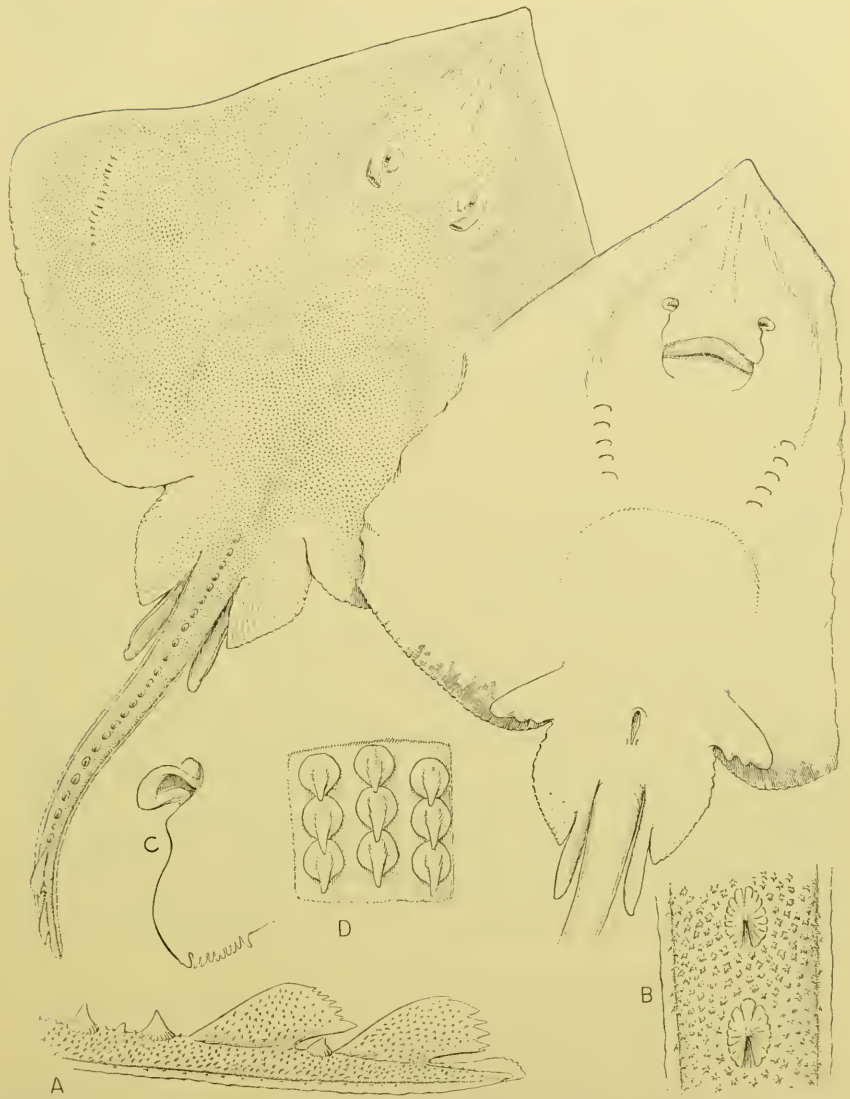


FIGURE 59. *Raja spinicauda*, male, 1,236 mm long, from off east coast of Newfoundland (Newfoundland Dept. Nat. Resources). *A* Side view of posterior part of tail, about 0.4×. *B* Dorsal view of tail at about midlength, about 0.8×. *C* Right-hand nostril and nasal curtain, about 0.6×. *D* Upper teeth, about 2.7×.

center of cloaca to first dorsal fin about 70 % as great as distance from center of cloaca to tip of snout, its length to tip nearly as great as distance from center of cloaca to snout in halfgrown specimens, relatively a little less in adults.

Disc smooth along a narrow marginal band rearward from tip of snout in males to maturity and probably in females as well; rough elsewhere with large prickles or small spines, closest together abreast of eyes, on outer parts of pectorals, and over rump region; sparser between orbits and outward from shoulders; males may develop scattered naked areas at maturity on central parts of pectorals; tail thickly and uniformly prickly above, sparsely so along lateral folds; disc without thorns (except for alar spines of males), but tail with a median row of 21–26 large and conspicuous thorns on strongly striate bases from a little anterior to axils of pectorals to first dorsal fin; also one large thorn in interspace between first and second dorsals; inner parts of pelvics prickly, outer portions smooth; dorsals prickly; caudal membrane smooth or with a few minute prickles. Alar spines of sexually mature males in 3–4 rows. Lower surface of disc smooth, but tail with a narrow prickly band along either margin rearward from axils of pelvics.

Snout anterior to orbits about 3.6 times as long as distance between orbits, its length in front of mouth about 2.5 times as great as distance between exposed nostrils. Orbit a little more than half as long as distance between orbits, and about as long as spiracle. Distance between first gill openings 2.1 times as long as distance between exposed nostrils, between fifth gill openings 1.7 times; first gill openings 1.2 times as long as fifth and about 17 % as long as breadth of mouth. Nasal curtain fringed with about 10 short rounded lobelets; expanded posterior (outer) margin of nostril smooth. Mouth nearly straight in females, a little arched in adult males.

Teeth $\frac{30-34}{25-33}$, with sharp thorn-like cusp on rounded base in both sexes, rather loosely spaced in regular transverse series, much as in *R. hyperborea* and *R. lintea*.

First and second dorsals about equal in size, brush-shaped, with jagged posterior margin on specimen seen. Interspace between dorsals a little less than half as long as base of first dorsal. Caudal membrane beyond second dorsal a little shorter than base of first dorsal. Pelvics deeply concave outwardly; anterior margin about 50 % as long as distance from its own origin to rear tip of pelvic; anterior lobe broadly rounded at tip and strongly scalloped along posterior edge, thus marking the positions of radial cartilages; posterior lobe with moderately convex and somewhat wavy outer margin, the rear tips subangular, reaching back about $\frac{1}{3}$ of the way from axils of pelvics toward first dorsal.

Anterior rays of pectorals extending forward about 85 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface uniformly pale brown or bluish gray without dark markings, paler or whitish around posterior edges of pectorals; lateral folds on tail either of same color as upper surface or white. Lower surface of disc white with small sooty blotches irregularly distributed around margins of pectorals; pelvics white below, sometimes with sooty margins; lower surface of tail white anteriorly but pale brown rearward from a

little posterior to axils of pelvics, crossed on posterior quarter by two irregular yellowish white bands.[153]

Relationship to Extralimital Species. In the southern hemisphere *R. spinicauda* has a close counterpart in *R. griseocauda* Norman 1937[154] of the Patagonian-Falkland Islands region. The resemblance between these two Skates is so close, in fact, that only a comparison of specimens from the two regions can show whether there are significant differences between them. The relationship between the members of this pair thus parallels that between *R. radiata* of the northern North Atlantic and *R. doello-juradoi* Pozzi 1933[155] of Argentina, Patagonia, and the Falkland Islands (p. 255). Among Skates of the northeastern Siberian-Bering Sea region, *R. violacea* Uvarov 1935[156] resembles *R. spinicauda* most closely. But the former has only about half as many thorns along the tail as *R. spinicauda*, and there is an extensive area free from prickles on either side of the mid-dorsal belt of its disc.

Size. Specimens measured (about nine males and females) have ranged from 740–1,720 mm in length, showing this to be one of the larger Skates of northern seas. A male 910 mm wide (hence about 1,340 mm long) with slender claspers was sexually mature.

Developmental Stages. Egg capsules, apparently of this species, in our Study Material (p. 272), measure 137 by 90 mm and 142 by 95 mm. They are of the usual quadrate shape, with nearly straight transverse outline at the end bearing the longer pair of horns, concave at the end with the shorter pair. The lateral flanges are narrow, continue out along the basal parts of the horns, and bear masses of fine filaments matted together and more or less interconnected by a delicate membrane, as is true of various other Skate eggs. In the preserved state these masses of filaments are irregularly scattered along the flanges (chiefly near their extremities); but they may have been continuous along the flanges when the eggs were first laid. On the larger specimen, one of the horns of the shorter pair is about 115 mm long, with filamentous tip; all of the horns on both of the specimens have lost their extremities. The most interesting feature of these capsules, and one that sets them apart from those of any other Atlantic Skates whose eggs are known, is that their entire surface, apart from the extremities of the horns and the lateral flanges, bears a great number of low narrow longitudinal ridges, each close-set with a single series of numerous stiff rod-like structures about two mm long, with complexly dissected tips. On one of our capsules there are between 140–150 ridges on each side, each with 200–220 or more rods, or a total upwards of 30,000 on each side, giving the capsule a velvety appearance.

Similar egg capsules, taken from shark's stomachs off Southwest Greenland, have already been credited to *R. spinicauda* because they were certainly not referable to any other Skate known from Greenland.[157] And their identity as egg cases of *R. spinicauda* is now made highly probable by the wedge-shaped anterior contour of the embryo con-

153. On specimen seen.
154. Discovery Rep., *16*, 1937: 26.
155. Physis B. Aires, *11*, 1935: 491; see also Norman, Discovery Rep., *16*, 1937: 15.
156. Bull. Acad. Sci. Leningrad [1935], 1935: 3, 431, 432, fig. 1.
157. Jensen, Mindeskr. Steenstr. Føds. Kbh., *2* [30], 1914: 33, figs. 10, 11; Spol. Zool. Mus. Hauniensis, 9, 1948: 56.

tained in one of those in our Study Material, combined with the presence of a single series of translucent dots along the mid-dorsal line of the tail, seemingly presaging the later development of caudal thorns, with no indication of future thorns anywhere on the disc.[158]

Habits. Nothing whatever is known of the way of life of *R. spinicauda* beyond the fact that the few specimens taken so far have come from depths of: 120–440 fathoms, where bottom temperatures ranged between 0.5 and 3.8° C (about 32 and 39° F) in West Greenland waters; 66–88 fathoms (120–160 m) off Iceland; 90–140 fathoms in Newfoundland waters, where the temperature of the bottom water was between +0.65 and −1.5° C; and, if our identification of two egg capsules in our Study Material (p. 275) is correct, 260–350 fathoms off southern Nova Scotia and on the continental slope off the southern part of Georges Bank. Several taken off Southwest Greenland had fed on capelin (*Mallotus*) and on the Starry Skate (*Raja radiata*).

Range. R. spinicauda is known definitely only from: Barents Sea; off the southeast coast of Iceland; from the Greenland side of Davis Strait, Lat. 65°14′ N, Long. 55° 55′ W; from Tunugdliarfik Fjord, Skovfjord, and Julianehaab,[159] Southwest Greenland; from the continental slope (91–127 fath.) off Cape Bonavista, east coast of Newfoundland; and from the deep trough of Hermitage Bay (90–140 fath.) on the south coast of Newfoundland (two specimens).[160] To judge from the distribution of these localities, it is to be expected also in other bays along the coasts of eastern Labrador and of eastern and southern Newfoundland, wherever the water is deep enough and the bottom temperature lower than 2–3° C (35–37° F); also around the slopes of the Grand Banks at suitable depths. And, if the identification of egg capsules in our Study Material is correct (p. 275), *R. spinicauda* ranges westward along the continental slope at least as far as the offing of southwestern Georges Bank.

Synonyms and References:

Raja spinicauda Jensen, Mindeskr. Steenstr. Føds. Kbh., *2* (30), 1914: 30, 33, 38, fig. 12, pl. not numbered (descr., color, meas., size, ills. adult and egg case, depths, temps., Davis Str. and fjords of SW. Greenland); Clark, Rep. Fish. Bd. Scot. (1926), 1, 1926: 49 (diagn., range, after Jensen, 1914); Faune Ichthyol. Cons. int. Explor. Mer, 1931: pl. not numbered (descr., size, ills., range, depth, egg cases, W. Greenland, after Jensen, 1914; and Western Horn, Iceland); Lundbeck, Mitt. dtsch. SeefischVer., *49*, 1933: 8 (Barents Sea); Jensen, Spol. Zool. Mus. Hauniensis, *9*, 1948: 49 (W. Greenland).

Raja teevani Bigelow and Schroeder 1951

Figure 59α

Study Material. Immature male, 558 mm in total length, type, in U. S. National Museum, and another immature male, 302 mm in total length, in Harvard Museum of Comparative Zoology, both from Lat. 29°11′ N, Long. 86°52′ W, 305 fathoms, Oregon St. 279.

158. Unfortunately the embryo is in poor condition.

159. Personal communication from Paul M. Hansen.

160. These Newfoundland captures, made during experimental fishing for halibut by the research vessel of the Newfoundland Department of Natural Resources, were reported to us by letter from W. Templeman, Director, to whom we are also indebted for the specimen pictured in Fig. 59.

Distinctive Characters. *Raja teevani* differs from all other rajids in the western North Atlantic in the shape of its tail which widens rearward toward the dorsal fins (in all other rajids it narrows rearward). It resembles *R. olseni* and *R. laevis* in general appearance and in lacking thorns along the midbelt of the disc from the level of the axils of the pectorals to the vicinity of the spiracles. But it differs from *olseni* in having no interspace between the bases of the dorsal fins. From *laevis* of comparable size it may be separated by its longer snout (distance from tip of snout to eye about $^1/_4$–$^1/_3$ the width of disc in *teevani*, but only about $^1/_5$ in *laevis*) and by the fact that the anterior margin of the pelvic fin is longer than the distance from its own origin to the rear tip of the pelvic (shorter in *laevis*).

Description. Proportional dimensions in per cent of total length. Male, 558 mm (U. S. Nat. Mus., No. 153557), and male, 302 mm (Harv. Mus. Comp. Zool., No. 37189), from the Gulf of Mexico.

Disc: extreme breadth 72.7, 73.5; length 58.2, 54.4.

Snout length: in front of orbits 22.2, 19.2; in front of mouth 24.2, 20.9.

Orbits: horizontal diameter 3.2, 3.5; distance between 4.1, 3.5.

Spiracles: length 2.0, 1.8; distance between 6.1, 6.3.

Mouth: breadth 7.7, 7.0.

Exposed nostrils: distance between inner ends 8.7, 8.3.

Gill openings: length, 1st 1.7, 1.2; 3rd 1.8, 1.3; 5th 1.2, 1.0; distance between inner ends, 1st 13.8, 14.4; 5th 8.4, 8.6.

First dorsal fin: vertical height 2.7, 2.3; length of base 4.3, 4.6.

Second dorsal fin: vertical height 2.7, 2.3; length of base 4.0, 4.6.

Pelvics: anterior margin 14.7, 14.0.

Distance: from tip of snout to center of cloaca 51.7, 47.0; from center of cloaca to 1st dorsal 34.3, 34.8; to tip of tail 48.3, 53.0; from rear end of 2nd dorsal base to tip of tail 5.4, 9.3.

Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc 1.25–1.35 times as broad as long, the maximum anterior angle in front of spiracles about 70°; anterior margins sinuous from snout to outer corners, convex opposite a little in front of orbits; outer corners sharply rounded; posterior margins gently convex; posterior corners broadly rounded. Axis of greatest breadth about 77 % of distance from tip of snout toward axils of pectorals. Tail with a lateral fold low down on each side beginning almost imperceptibly about opposite tips of pelvics, widening rearward and ending opposite middle of caudal fin; its length from center of cloaca to origin of first dorsal fin 0.66–0.74 as great as, to its tip 0.93–1.1 times as great as, distance from center of cloaca to tip of snout.

One or two small thorns along inner anterior margin of orbit and another one on posterior margin; minute prickles scattered over interorbital area and over entire disc anterior to orbits; tail with a median row of 15 thorns pointing backward, beginning about an eye's diameter posterior to axils of pelvics and ending a little in front of first

FIGURE 59α. *Raja teevani*, male, 558 mm long, from offing of Pensacola, Florida, Lat. 29°11′ N, Long. 86°52′ W (U. S. Nat. Mus., No. 153557, type). *A* Upper teeth, about 6×. *B* Margin of left nasal curtain, about 2.5×. *C* Posterior part of tail, about 1×. *D* Mouth and nostrils, about 1×.

dorsal, the thorns somewhat more closely spaced and larger rearward than near row's origin; on tail, minute prickles from about tips of pelvics nearly to tip; dorsals and caudal with a few minute prickles. Lower surface with a band of prickles along anterior margins of disc from a little posterior to level of mouth to tip of snout, and also along anterior half of rostral cartilage.

Snout in front of orbits 5.5–6.9 times as long as orbit; its length in front of mouth 2.5–3.6 times as great as distance between exposed nostrils. Orbit 1.6–1.8 times as long as spiracle; distance between orbits 1.0–1.3 times as great as orbit. Distance between first gill openings 1.6–1.7 times as great as distance between exposed nostrils, between fifth gill openings about 1.0 times; first gill openings 1.2–1.4 times as long as fifth and 0.17–0.22 as long as breadth of mouth. Nasal curtain fringed; expanded posterior (outer) margins of nostrils smooth except for a few fringes on extreme outer angle. Upper and lower jaws moderately arched centrally.

Teeth $\frac{36-38}{36-38}$, rather widely spaced, in quincunx, triangular or ovate, with smooth rounded apex on outer margin and a low triangular cusp, pointing inward, on inner margin.

First and second dorsals similar in size and shape. No interspace between dorsals. Caudal membrane from rear end of base of second dorsal 1.25–2.0 times as long as base of first dorsal. Pelvics deeply concave, strongly scalloped along anterior side of excavation but only weakly so rearward; anterior margin 1.1 times as long as distance from its own origin to rear tips of pelvics; anterior lobe moderately slender, including five radial cartilages besides the first stout one; posterior lobe convex outwardly; rear tips abruptly rounded, extending about $^1/_5$ of the distance from axils of pelvics toward first dorsal; inner margin straight.

Rostral cartilage firm, narrow, extending to tip of snout. Anterior pectoral rays reaching only about $^2/_5$ of distance from level of front of orbits toward tip of snout. Translucent area in front of orbits and on either side of rostral cartilage very thin and membranous.

Color. Upper surface of larger specimen pale brown, somewhat darker along posterior margins of disc, on pelvics, and on tail. Dorsal fins and caudal black. Below, creamy on disc except somewhat dusky along outer margins from outer angle rearward and on pelvics. Tail blackish. On the smaller specimen there is a narrow black margin along the posterior edge of the disc above, and the lower surface is distinctly margined with black rearward from the level of the mouth; the rear parts of the pelvics are blackish also.

Size and Habits. The small claspers on the larger specimen indicate that this species attains at least a moderately large size. Nothing is known of its habits beyond the fact that our two specimens were taken at a depth of 305 fathoms.

Occurrence. It is known only from the offing of Pensacola, Florida.

Reference:

Raja teevani Bigelow and Schroeder, J. Wash. Acad. Sci., *41* (12), 1951: 388 (descr., ill., off Pensacola, Fla.).

Raja texana Chandler 1921

Texas Skate

Figures 60, 61

Study Material. Thirteen specimens, 105–550 mm long, from Barataria and Chauvin, Louisiana and from Austin, Texas, in the collections of the U. S. National Museum,

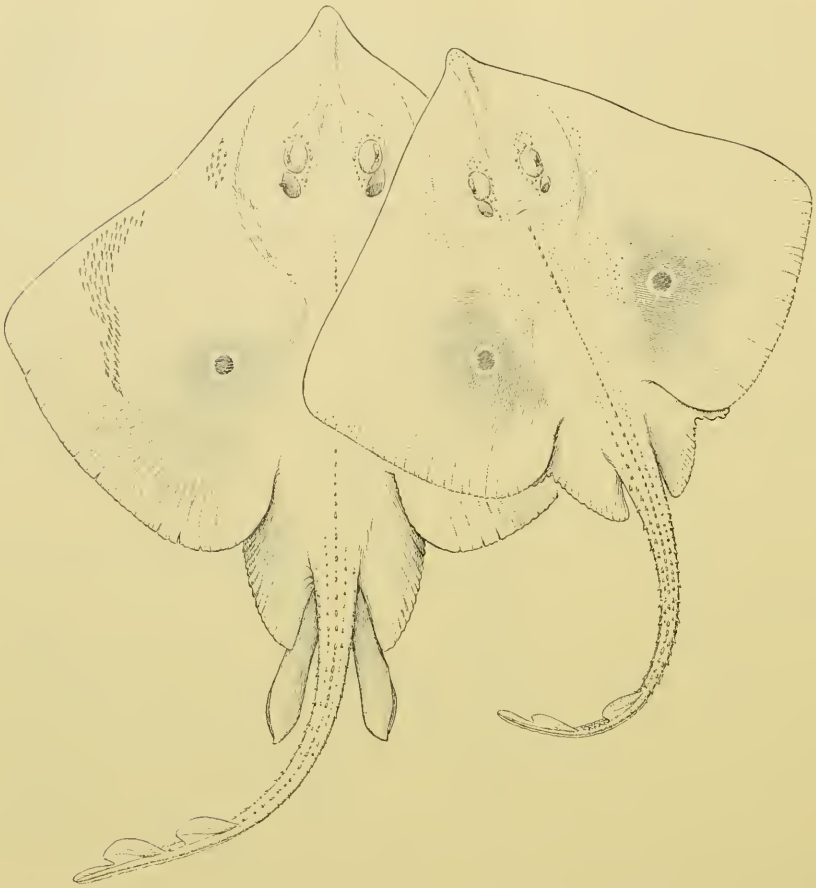


FIGURE 60. *Raja texana*, male, 468 mm long, from Barataria, Louisiana (U. S. Nat. Mus., No. 127294) and female, 387 mm long, from Chauvin, Louisiana (Amer. Mus. Nat. Hist., No. 16351).

American Museum of Natural History, and Harvard Museum of Comparative Zoology, including a 468-mm male, close to maturity; also an embryo 87 mm long, with large yolk sac, probably of this species, from Cortez, Florida. Other specimens from Galveston, Aransas Pass, and Corpus Christi, Texas, in the U. S. National Museum were also examined.

Distinctive Characters. The most striking feature of *R. texana* (and of *R. ackleyi* as well) is its color pattern with a single conspicuous dark-centered ocellar spot on the

inner part of each pectoral. This in itself is enough to distinguish it (and *ackleyi*) from all other Skates of the western North Atlantic, except for specimens of *R. ocellata* which are marked with one large ocellar spot on each side (p. 246). And the disc and tail of *R. ocellata* are so much thornier than those of *R. texana*, and its anterior contour is so much more obtusely rounded, that the two could hardly be confused. The only Skate of the western South Atlantic that closely parallels *R. texana* (and *R. ackleyi*) in color pattern is *R. cyclophora* Regan 1903[161] from Brazil, but the outer corners of the pectorals of *R. cyclophora* are angular as contrasted with the rounded disc of *R. texana*. *R. texana* is distinctive also in that the thorns on the mid-dorsal row are much smaller[162] between the pectoral and pelvic arches than they are forward to the nose and rearward along the tail; and, while the inner margins of the orbits are thorny, there are no thorns on the shoulder regions. *R. texana* is closely allied to *R. ackleyi* (p. 155), but it appears to be distinguishable from the latter by its relatively wider disc with abruptly rounded outer corners (broadly rounded on *R. ackleyi*), by its color, the upper surface of its disc lacking the small light and dark spots that mark *R. ackleyi*, and by the shape of the ocellar spots, which are round in *R. texana* but oval in *R. ackleyi*.

Description. Proportional dimensions in per cent of total length. Male, 293 mm, from Freeport, Texas (Harv. Mus. Comp. Zool., No. 35845). Female, 387 mm, from near Chauvin, Louisiana (Amer. Mus. Nat. Hist., No. 16351).

Disc: extreme breadth 62.3, 64.2; length 46.1, 50.8.
Snout length: in front of orbits 13.5, 14.5; in front of mouth 15.0, 15.5.
Orbits: horizontal diameter 3.1, 3.4; distance between 4.8, 4.2.
Spiracles: length 2.6, 2.3; distance between 6.3, 6.1.
Mouth: breadth 7.5, 7.5.
Nostrils: distance between inner ends 8.0, 7.7.
Gill openings: lengths, 1st 1.2, 1.4; 3rd 1.5, 1.7; 5th 1.2, 1.2; distance between inner ends, 1st 14.7, 14.5; 5th 8.5, 8.0.
First dorsal fin: vertical height 2.0, 1.8; length of base 5.8, 5.7.
Second dorsal fin: vertical height 1.7, 1.6; length of base 6.1, 5.2.
Pelvics: anterior margin 9.6, 10.3.
Distance: from tip of snout to center of cloaca 44.7, 46.5; from center of cloaca to 1st dorsal 37.5, 34.4; to tip of tail 55.3, 53.5; from rear end of 2nd dorsal base to tip of tail 3.8, 4.7.
Interspace between: 1st and 2nd dorsals 2.2, 3.6.

Disc about 1.2–1.3 times as broad as long; maximum anterior angle in front of spiracles about 106° in smaller specimens, about 95° in half-grown, about 90° in adult males, and about 85° in adult females; snout rather noticeably projecting, rounded at tip; anterior margins weakly concave just posterior to tip of snout, then bulging slightly and becoming weakly concave again opposite spiracles in both sexes; outer corners

161. See Ribeiro (Arch. Mus. nac. Rio de J., 7, 1914: pl. 16) for photograph of *R. cyclophora*.
162. On some specimens the thorns in the midrow may be absent for a short space about in line with the two ocellar spots.

rather abrupt, posterior corners broadly rounded, posterior margins weakly convex. Axis of greatest breadth about 70 % of distance back from snout toward axils of pectorals. Tail with lateral folds extending nearly its entire length but so narrow that they are likely to be overlooked; distance from center of cloaca to origin of first dorsal 70–80 % as great as distance from snout to cloaca, the variation depending upon the position of first dorsal relative to second dorsal rather than on size or sex; extreme length of tail, from center of cloaca to tip, about 1.1–1.2 times as great as distance from center of cloaca to snout.

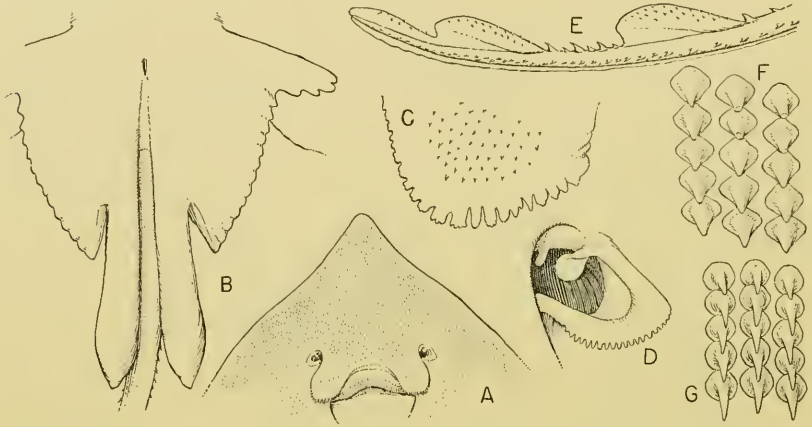


FIGURE 61. *Raja texana*. *A* Lower side of anterior part of head of male pictured in Fig. 60. *B* Ventral view of pelvics of same. *C* Margin of right-hand nasal curtain of same, about 4×. *D* Left-hand nostril of same, about 4×. *E* Side view of posterior part of tail of female pictured in Fig. 60. *F* Upper teeth of another female, 550 mm long, from Galveston, Texas (Harv. Mus. Comp. Zool., No. 36389), about 7×. *G* Upper teeth of male, 418 mm long, from Freeport, Texas (Harv. Mus. Comp. Zool., No. 36393), about 7×.

Small specimens, up to 150–200 mm long, with rostral ridge either smooth or bearing 2–3 small thorns; 2–3 larger thorns in front of orbit and one close behind it; usually three in midline of back from nuchal region to shoulder girdle, these followed by a gap and then by a continuous row of 16–17 thorns from pelvic girdle to first dorsal fin; 1–3 thorns between first and second dorsals; also one irregular row low down either side of tail from a little posterior to axils of pectorals nearly to tip; first and second dorsals with a few prickles; upper surface smooth otherwise except for thorns. Half-grown specimens and larger with the midrow of thorns continuous from nuchal region rearward to first dorsal, about eight large ones anterior to pectoral girdle, several small ones between pectoral girdle and pelvic girdle, 42–47 larger ones on tail, and 1–3 up to 6–7 smaller ones in interspace between first and second dorsals;

also two rather regular rows of thorns a little larger than those of the median row[163] on each side of tail and extending nearly to tip; 9–10 thorns around orbit, and a patch of smaller thorns inward from spiracle. Tip of snout and rostral ridge, space between spiracles, midbelt of disc back to pelvic girdle, and outer margins abreast of eyes (smooth on small specimens) developing a few scattered prickles with growth. Maturing males developing 12–13 large thorns near margins of disc opposite eyes but losing the prickles from midbelt of disc. Alar spines of mature males in several irregular rows, covering a roughly triangular area that extends forward along margins of pectorals past level of posterior edges of spiracles, the innermost row longest. Lower surface entirely smooth on small specimens; prickles, interspersed with small thorns, developing on tip of snout with growth; also, prickles developing along outer anterior margins of disc finally roughen entire lower surface of head rearward to about the mouth on males and along the median belt about as far as fifth gill openings in females; lower side of extremity of tail prickly on females but smooth on males.

Snout in front of orbits about 3.3–4.0 times as long as orbit in young of both sexes and in males to maturity, about 4.5–5.0 times in mature females; its length in front of mouth about 1.6–1.8 times as long as distance between nostrils in young and in mature males, about 2.0–2.2 times in large females. Distance between first gill openings 1.8–2.0 times as long as distance between exposed nostrils, about equal between fifth gill openings; first gill openings 1.0–1.2 times as long as fifth and about 16–27 % as long as breadth of mouth. Nasal curtain and expanded posterior (outer) margin of nostril each with shallow fringe. Mouth nearly straight in females, lower jaw a little more arched in mature males.

Teeth $\frac{44-48}{42-48}$; those of small and half-grown specimens close-set in quincunx, with nearly circular base and stout conical cusp on all except those of the oldest row; those of adults of both sexes spaced more loosely in transverse series with well developed cusp; uppers of males a little more slender than those of females, the lowers conspicuously so.

Dorsals similar in size and shape, posterior margin more or less re-entrant. Interspace between first and second dorsals varying from only about 30 % as long, to about as long, as base of first dorsal. Caudal membrane posterior to second dorsal about as long as base of first dorsal. Pelvics moderately concave outwardly, strongly scalloped around the indentation; anterior margin about 67–72 % as long as distance from its own origin to rear tip of pelvic; anterior lobe noticeably small but including three or four slender radials besides the first stout one; posterior lobe with weakly convex outer margin; rear tip broadly rounded in female but narrowly so in mature male, extending back about 10–16 % of distance from axils of pelvics toward tip of tail in young and adult female, about 20 % in adult male. Claspers of sexually mature male reaching back a little more than halfway from axils of pelvics toward first dorsal.

Anterior rays of pectorals reaching about 51–56 % of distance from level of fronts of orbits toward tip of snout.

163. This contrast in size is the reverse of what is usual among Skates of the western North Atlantic.

Color. Upper surface rich chocolate or coffee brown except for a translucent area on either side of rostral cartilage, with indistinct pale spots and blotches irregularly distributed, most conspicuous on small specimens but perhaps entirely lost on some adults; also a single conspicuous dark brown or black ocellar spot bordered with yellow on inner part of each pectoral a little posterior to axis of greatest breadth. Lower surface plain white.

Size. A male 468 mm long is close to sexual maturity, as indicated by the sexual spines and claspers. The largest specimen is 537 mm long (see Study Material, p. 280).

Habits. Nothing whatever is known of the habits of this species, except that most of them have been taken from shallow water, the deepest being 37 fathoms for a newborn specimen trawled off Aransas Pass, Texas.

Range. Known only from the west coast of Florida (Cortez and Englewood), from the coast of Mississippi, where it is reported to us as fairly common;[164] from Louisiana (Barataria, Chauvin); and from Texas (Aransas Pass, Corpus Christi, Austin, Galveston, Houston); hence it is probably restricted to the Gulf of Mexico.

Synonyms and References:

Raia texana Chandler, Proc. U. S. nat. Mus., *59*, 1921: 657 (descr., Houston, Texas); Baughman, Copeia, 1943: 133 (*R. texana* Chandler 1921 antedates *R. texana* Leriche 1940, a fossil; *stellata* proposed as substitute for latter).

Raja texana Springer, Copeia, 1939: 237 (descr. egg case, Englewood, Florida); Woods, Copeia, 1942: 191 (meas., near Corpus Christi, Texas); Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 21 (size, temp., sal., Texas).

Genus *Breviraja* Bigelow and Schroeder 1948

Breviraja Bigelow and Schroeder, J. Mar. Res., 7 (3), 1948: 548, 558; type species, *B. colesi* Bigelow and Schroeder 1948.

Generic Synonyms:

Raja (in part) Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 236; Mem. Harv. Mus. comp. Zool., *36*, 1913: 335; for *R. plutonia* Garman 1881.

Malacorhina (in part) Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 237 (suggests *R. plutonia* may be a *Malacorhina* because of short rostral cartilage.)

Generic Characters. Pelvics not completely divided, although their margins may be so deeply concave that the fin is definitely bilobed. Tip of rostral projection of cranium falling short of level of anterior extremities of pectoral rays and falling shorter still of tip of snout; anterior rays of pectorals reaching nearly to level of tip of snout. Characters otherwise as in *Raja*.

Size. Some of the species are small, males maturing at lengths no greater than 200–300 mm, as indicated by the condition of the claspers, but others grow larger.

Developmental Stages. Presumably oviparous, but the eggs have not been seen.

Habits and Range. They appear to be confined to moderately deep water, with the recorded depths of capture ranging from 200 to 500 fathoms. Beyond this nothing

164. Personal communication from Stewart Springer.

FIGURE 62. X-ray photographs, slightly retouched, to show rostral cartilage and foward extension of pectoral radials in *Breviraja:* Upper left, *B atripinna;* upper right, *B. colesi;* middle left, *B. cubensis;* middle right, *B. plutonia;* lower left, *B. spinosa;* lower right, *B. sinus-mexicanus.*

is known of their habits. So far the genus is known only along the north and south coasts of Cuba, in the northern part of the Gulf of Mexico off Pensacola, Florida, and northward along the continental slope of the southeastern United States to the offing of South Carolina, the most northerly record (for a specimen of *B. plutonia*) being Lat. 32°43′ N, Long. 77°21′ W. But it may prove that some short-nosed Skates from other parts of the world that are now referred to *Raja* actually belong in this genus.

Species. Seven species of this genus have been discovered, six of them recently; the seventh (*plutonia* Garman 1881) was usually referred to *Raja* until *Breviraja* was recently separated from it, though the suggestion had been made in the original account of the species that the rostral cartilage might remain undeveloped. For a Key to Species, see p. 147.[1]

Breviraja atripinna Bigelow and Schroeder 1950

Black-fin Skate

Figures 62 (upper left), 63

Study Material. One male and two females, 187–278 mm long, trawled by the research vessel Atlantis off Santa Clara Province on the north central coast of Cuba in 250–500 fathoms, in the Harvard Museum of Comparative Zoology.[2]

Distinctive Characters. B. atripinna falls with *B. sinus-mexicanus* and with the *B. cubensis*-and-*plutonia* group in that its tail is of a great length. But it is separable from all three of these species by its relatively longer rostral cartilage. Halfgrown and larger specimens also differ conspicuously from *B. sinus-mexicanus* in having a relatively much longer interspace between the dorsal fins. Very young *B. atripinna* more nearly resemble *B. sinus-mexicanus* in this respect, but the tail of *B. atripinna* is so much less thorny than that of the latter (cf. Fig. 63 with 69, 70) that there is little danger of confusing the two. The plain coloration of its disc, without dark markings, is a convenient field mark for distinguishing *atripinna* from *cubensis* and from *plutonia.*

Description. Proportional dimensions in per cent of total length. Male, 225 mm, and female, 278 mm, from Cuba (Harv. Mus. Comp. Zool., Nos. 36367 and 36370, respectively).

Disc: extreme breadth 44.5, 45.3; length 37.3, 38.5.
Snout length: in front of orbits 8.9, 9.7; in front of mouth 12.0, 12.6.
Orbits: horizontal diameter 4.0, 5.0; distance between 2.7, 2.7.
Spiracles: length 2.2, 1.9; distance between 6.0, 6.1.
Mouth: breadth 5.3, 5.0.
Nostrils: distance between inner ends 5.8, 5.9.
Gill openings: lengths, 1st 1.3, 1.3; 3rd 1.3, 1.3; 5th 1.2, 1.2; distance between inner ends, 1st 9.8, 10.0; 5th 5.8, 6.1.
First dorsal fin: vertical height 1.5, 1.3; length of base 4.2, 4.7.

1. *Breviraja* combined with *Raja.*
2. Atlantis Sts. 2985, 3443, 3459 (Harv. Mus. Comp. Zool., Nos. 36367, 36370 type, 36371).

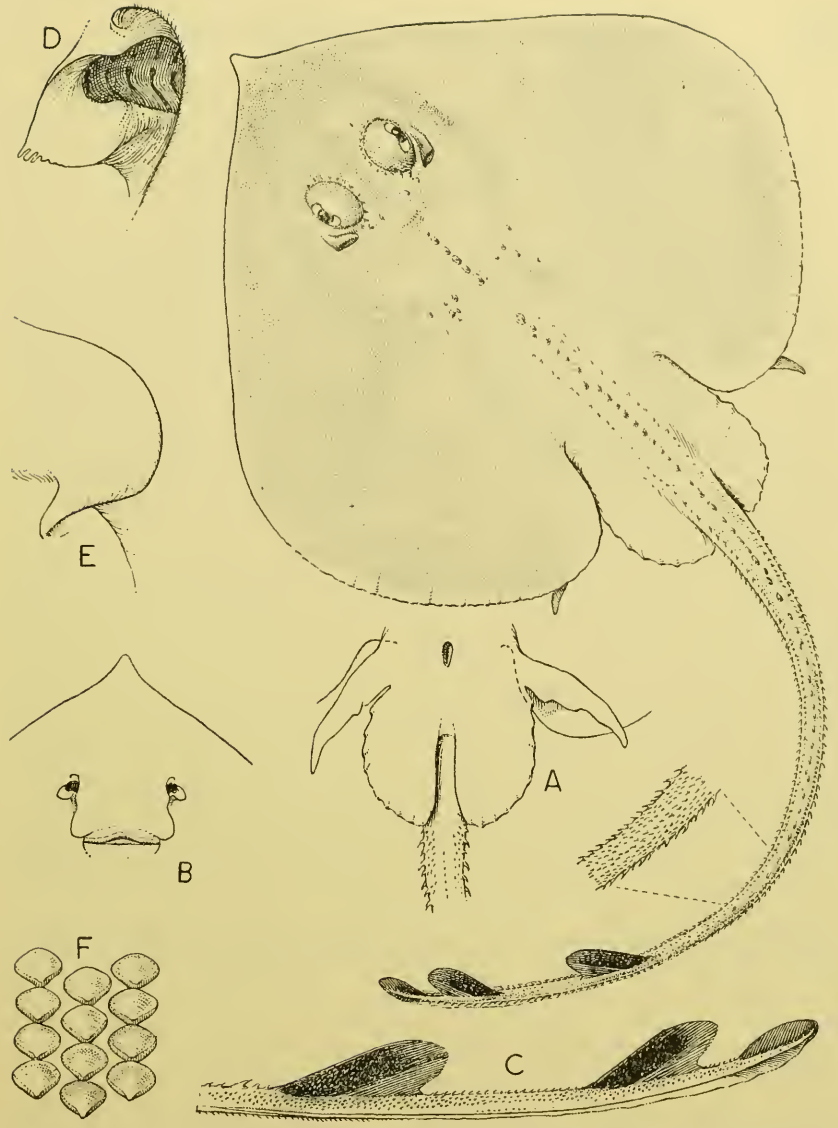


FIGURE 63. *Breviraja atripinna*, female, 278 mm long, from off Santa Clara Province, north coast of Cuba, Lat. 23°22′ N, Long. 79°53′ W, ATLANTIS St. 3443 (Harv. Mus. Comp. Zool., No. 36370, type). *A* Ventral view of pelvics. *B* Lower surface of anterior part of head to show nostril and mouth. *C* Side view of posterior part of tail, about 2.1×. *D* Right-hand nostril, about 7.9×. *E* Margin of left-hand nasal curtain, about 5.2×. *F* Upper teeth.

Second dorsal fin: vertical height 1.5, 1.4; length of base 4.0, 3.6.
Pelvics: anterior margin 10.7, 11.8.
Distance: from tip of snout to center of cloaca 35.6, 35.7; from center of cloaca to 1st dorsal 48.0, 47.0; to tip of tail 64.4, 64.3.
Interspace between: 1st and 2nd dorsals 4.5, 5.0; 2nd dorsal and tip of tail 3.5, 4.0.

Disc about 1.2 times as broad as long, snout projecting only slightly on newborn specimens but more conspicuously on larger ones, tip narrowly blunted; maximum anterior angle in front of spiracles about 115° on small specimens, about 100° on larger; anterior margins weakly convex anterior to orbits, thence nearly straight to the broadly rounded outer corners; posterior margins evenly and moderately convex, posterior corners broadly rounded, inner margins straight toward axil. Axis of greatest breadth about 75 % of distance back from tip of snout toward axils of pectorals. Tail slender, its lateral folds narrow and confined to posterior two-thirds, widening rearward to opposite second dorsal; its length to first dorsal about 1.4 times as great as distance from center of cloaca to tip of snout and about 1.8 times as great to tip in large specimens; a little longer relatively in smaller specimens.

Upper surface around posterior margins of pectorals and on tip of snout smooth, disc and tail rough elsewhere with small and sharp close-set prickles, many of them covered over with pigmented skin; inner margin of orbit to inner end of spiracle with a single series of small thorns, 7–8 on small and 12–15 on older specimens; 2–3 thorns inward from each spiracle; two on each shoulder of young increasing to 3–5 on older ones; midline of back with a row of thorns—about six from nuchal region to pectoral girdle, then a gap followed by about 60 smaller thorns along posterior part of disc and on tail to first dorsal fin; thorns in midline paired here and there side by side and more widely spaced rearward, decreasing in regularity with growth; an additional irregular band of small thorns on either side of posterior part of mid-dorsal ridge from about opposite axils of pectorals rearward, losing its identity among prickles of tail; also a row of small thorns along lower edge of tail on either side to a little in advance of first dorsal; anterior two-thirds of dorsals as well as interspace between them prickly, but caudal membrane smooth; pelvics prickly except at margins. Alar spines of adult male not seen. Lower surface of disc and pelvics smooth; tail also smooth below on very young specimens but more or less roughened with prickles on larger specimens.

Snout in front of orbits about three times as long as orbit on young, about two times on older specimens; its length in front of mouth 2.0–2.3 times as great as distance between exposed nostrils. Orbit about 1.6–2.6 times as long as spiracle; about 1.2–1.5 times as long as distance between orbits on young specimens, about two times on largest specimen seen. Distance between first gill openings 1.7 times as long as distance between exposed nostrils, between fifth gill openings 1.0 times; first gill openings about as long as fifth and about 25 % as long as breadth of mouth. Nasal curtain smooth-edged, posterior (outer) margin of nostril with a few marginal lobelets about midway of its length. Mouth slightly arched centrally.

Teeth about $\frac{40}{40}$; close-set in transverse series in both sexes, with low conical cusp on females and immature males.

First and second dorsals similar in shape, the base of first about 1.1–1.3 times as long as base of second. Interspace between first and second dorsals increasing in relative length from about 40 % as long as base of first dorsal on very young specimens to about as long as base of first dorsal on large. Caudal membrane about as long as base of second dorsal. Pelvics deeply concave outwardly and scalloped around the indentation; anterior margin slightly shorter to slightly longer than distance from its own origin to rear tip of pelvic; anterior lobe narrowing to a pointed tip, with 2–3 radials besides the first and stoutest; outer margin of posterior lobe rather strongly convex and weakly scalloped, rear tip well rounded, reaching back about $\frac{1}{4}$ the distance from level of axils of pectorals toward first dorsal. Claspers of mature males not seen.

Rostral cartilage narrow, extending about 75 % of distance from front of cranium toward tip of snout; anterior rays of pectorals about 85–90 % of that distance.

Color. Upper surface of disc, pelvics, and tail pale pinkish brown without distinctive markings; dorsals and caudal membrane pale and translucent on newborn specimens but soon turning brownish black and thus becoming conspicuous; lateral folds on tail transparent anteriorly but brownish black posteriorly to second dorsal. Lower surface plain whitish on small specimens, later becoming clouded with chocolate brown; darkest on abdomen and anterior lobes of pelvics while remaining whitish on median region of head from snout to first gill openings; anterior part of tail opposite pelvics with a chocolate blotch on large specimens.

Size. The claspers of a male 225 mm long still fall short of the tips of the pelvics, making it likely that this Skate does not mature until larger than other known species of its genus; the size at maturity is not known.

Developmental Stages. The eggs have not been seen.

Habits. The facts that the three specimens seen so far were trawled by the ATLANTIS at 250–500 fathoms and that none were taken in the many shoaler hauls around Cuba show that it is a deep-water species.

Range. Known only off the north central coast of Cuba.

Reference:

Breviraja atripinna Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103* (7), 1950: 390 (descr., ills., depth, off N. Central Cuba).

Breviraja colesi Bigelow and Schroeder 1948

Figures 62 (upper right), 64, 65

Study Material. Four males and four females, 81–333 mm long, including the type,[3] trawled by the research vessel ATLANTIS off the north and south coasts of Cuba, in the Harvard Museum of Comparative Zoology.

3. Type specimen, a female 333 mm long (Harv. Mus. Comp. Zool., No. 36374).

Distinctive Characters. B. colesi is marked off from all other known members of its genus in the western Atlantic by a tail that is at least no longer from the axils of the pelvics to the origin of the second dorsal than from the axils of the pelvics to the tip of the snout, by the fact that the midzone of the disc between the pectoral and pelvic girdles bears only one or two conspicuous thorns, if any, and by the dark markings on its upper surface. The shortness of its rostral cartilage separates it from the hard-nosed Skates of the genus *Raja*.

Description. Proportional dimensions in per cent of total length. Male, 294 mm (Harv. Mus. Comp. Zool., No. 36497), female, 333 mm (Harv. Mus. Comp. Zool., type, No. 36374), from Cuba.

Disc: extreme breadth 49.3, 48.0; length 41.5, 45.9.
Snout length: in front of orbits 8.3, 9.8; in front of mouth 8.8, 11.2.
Orbits: horizontal diameter 4.8, 4.5; distance between 2.5, 3.0.
Spiracles: length 2.9, 2.8; distance between 5.8, 5.7.
Mouth: breadth 7.1, 6.3.
Nostrils: distance between inner ends 6.5, 6.6.
Gill openings: lengths, 1st 1.4, 1.8; 3rd 1.4, 1.8; 5th 1.3, 1.5; distance between inner ends, 1st 12.2, 13.6; 5th 5.8, 6.6.
First dorsal fin: vertical height 1.4, 1.5; length of base 4.8, 3.6.
Second dorsal fin: vertical height 1.0, 1.5; length of base 4.1, 3.6.
Pelvics: anterior margin 10.5, 10.2.
Distance: from tip of snout to center of cloaca 38.4, 41.4; from center of cloaca to 1st dorsal 51.0, 50.0; to tip of tail 61.6, 58.6; from rear end of 2nd dorsal base to tip of caudal 1.4, 1.5.
Interspace between: 1st and 2nd dorsals 0.3, 0.0.

Disc about 1.0–1.2 times as broad as long, very obtuse in front; tip of snout marked by a small rounded prominence; maximum anterior angle in front of spiracles about 135°; anterior margins moderately and evenly convex on young and on females to maturity but weakly concave opposite and posterior to spiracles on adult males; outer corners well rounded, more broadly so on adult males than on females; posterior corners broadly rounded, merging into convex inner margins. Axis of greatest breadth about 70 % of distance back from tip of snout toward axils of pectorals. Tail with narrow lateral folds for entire length from a little behind tips of pelvics, widening posteriorly; its length from center of cloaca to origin of first dorsal about 1.2–1.3 times as great as distance from center of cloaca to snout, about 1.3–1.5 times as great to origin of second dorsal, and about 1.4–1.6 times as great to tip.

Disc rough with small prickles on adults of both sexes except close along anterior and posterior edges; a narrow band of thorns along anterior margins from level of spiracles forward, very small on females, larger on adult males; a cluster of small thorns on rostral ridge about halfway between level of fronts of orbits and tip of snout; 10–11 thorns around inner margin of orbit, the row interrupted midway; two thorns inward

FIGURE 64. *Breviraja colesi*, male, 320 mm long, from off Santa Clara Province, north coast of Cuba, Lat. 22°50′ N, Long. 79°08′ W, ATLANTIS St. 3423, 245 fathoms (Harv. Mus. Comp. Zool., No. 36447) and female, 333 mm long, from same general region, Lat. 23°12′ N, Long. 81°23′ W, ATLANTIS St. 3483, 285 fathoms (Harv. Mus. Comp. Zool., No. 36374, type).

from inner end of each spiracle; 4–5 on each shoulder; a median row of about six larger thorns from nuchal region to pectoral girdle, followed by 5–6 smaller ones more widely spaced to level of axils of pectorals, then by about 40–44 larger ones more closely spaced along tail; also, each side of tail with 2–3 irregular rows, the thorns successively a little larger and more closely spaced rearward to first dorsal, followed by smaller

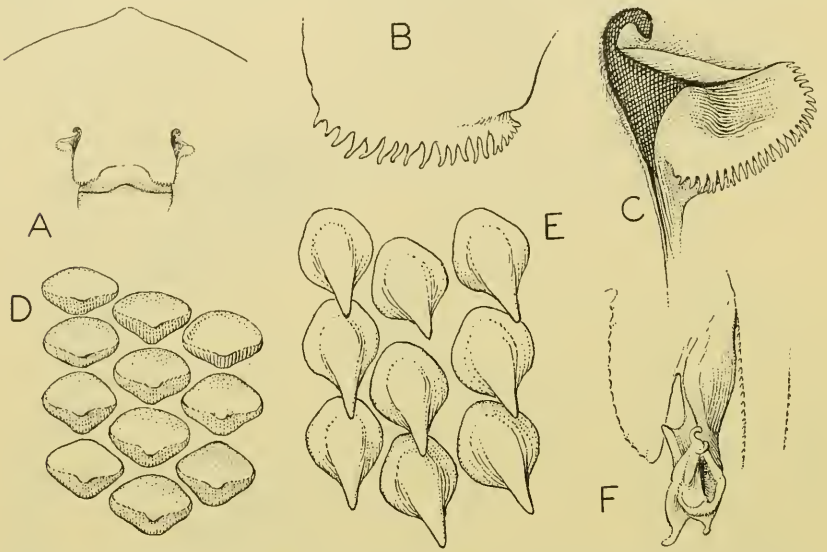


FIGURE 65. *Breviraja colesi*. *A* Mouth and nostrils of female illustrated in Fig. 64. *B* Margin of right-hand nasal curtain of same, about 5.6×. *C* Left-hand nostril of same, about 5.6×. *D* Upper teeth of same, near center of jaw, about 17×. *E* Upper teeth, near center of jaw, of male illustrated in Fig. 64, about 17×. *F* Dorsal view of tip of clasper of another mature male, from off north coast of Cuba, about 0.7×.

ones below dorsals; pelvics of females with a few small prickles on central part of posterior lobe, those of adult males smooth; dorsals prickly along upper parts; caudal membrane sparsely prickled. Very small specimens with fewer thorns around orbits, only 1–2 on each shoulder, 3–4 in median row from nuchal region to pectoral girdle; thorns on tail in more regular rows than on adults. Alar spines of sexually mature males in 2–3 rows near outer corners of pectorals. Lower surface smooth.

Snout in front of orbits about 1.7–2.2 times as long as orbit, its length in front of mouth about 1.4–1.7 times as great as distance between exposed nostrils. Orbit about 1.5–1.9 times as long as distance between orbits and about 1.6 times as long as spiracle. Distance between first gill openings 1.9–2.1 times as long as distance between exposed nostrils, 1.0–1.1 times between fifth gill openings; first gill openings about as long as fifth and about 20–30 % as long as breadth of mouth. Nasal curtain

deeply fringed, posterior (outer) margin of nostril finely so. Mouth moderately arched centrally.

Teeth about $\frac{42-50}{42-50}$, close-set in quincunx in females to maturity, with low conical cusp on ovate base; mature males with longer and sharper cusp.

First and second dorsals similar in size and shape, confluent at base or with short interspace; caudal membrane posterior to second dorsal only about $^2/_5$ as long as base of second dorsal. Pelvics deeply and sharply concave outwardly, weakly scalloped; anterior margin about 57–62 % as long as distance from its own origin to rear tip of pelvic; anterior lobe with narrowly rounded tip, including only two radials besides the stoutest; posterior lobe moderately convex on females, less so on adult males, its rear corner narrowly rounded, reaching back about $^1/_3$ the distance from axils of pectorals toward first dorsal. Claspers of sexually mature males reaching back about $^1/_3$ the distance from axils of pelvics toward first dorsal, their tips with blade-like expansion and complex arrangement of hooked processes.

Rostral projection from cranium triangular, forming an angle of about 40°, extending rigidly for about 60–75 % of the distance from front of cranium toward tip of snout.

Color. Upper surface of disc pale brown, mottled with irregular spots and blotches of darker brown, more numerous on some specimens than on others; outer part of disc with a variable number of larger rounded spots with pale centers and brown margins; also one on center of posterior lobe of each pelvic; tail with various brown markings, some forming crossbars that may number 7–8, more definitely outlined on young specimens than on adults, its lateral folds whitish; upper anterior part of each dorsal with a bronze blotch; another at anterior end of base of first dorsal on some specimens, not on all. Lower surface of disc and of tail pale yellowish or whitish.

Size. Apparently this species does not reach a length of much more than 400 mm, for the claspers of a male 320 mm long (Fig. 64) appear to be fully formed.

Developmental Stages. Nothing is known except that a young specimen with disc only 43 mm wide bears a close resemblance to the adults.

Habits. All specimens taken have been trawled in depths ranging from 200–285 fathoms.

Range. Known only from Cochinas Bay on the south coast of Cuba and off Matanzas and Santa Clara provinces on the north coast.

Reference:

Breviraja colesi Bigelow and Schroeder, J. Mar. Res., 7 (3), 1948: 559 (descr., ills., off N. and S. coasts of Cuba).

Breviraja cubensis Bigelow and Schroeder 1950

Figures 62 (middle left), 66

Study Material. Seventy specimens, male and female, 68–221 mm long, including the type, trawled by the research vessel Atlantis off North Central Cuba at 235–

405 fathoms,[4] in the Harvard Museum of Comparative Zoology; two specimens trawled off St. Augustine, Florida, at 373 fathoms,[5] in U. S. National Museum.

Distinctive Characters. B. cubensis falls with *B. sinus-mexicanus*, *B. atripinna*, and *B. plutonia* because of the great length of its tail. But it is easily separable from *B. sinus-mexicanus* by the facts that its tail posterior to the tips of the pelvics is not conspicuously thorny, that it has only prickles and no thorns along its rostral ridge, and that the prickles on its disc and tail are not densely pigmented. The dark markings on its disc and the dark bars on its tail serve to distinguish it from *B. atripinna*, which is plain-colored. It resembles *B. plutonia* closely in general form, and some specimens have much the same color pattern; but the anterior lobes of the pelvics are relatively smaller in *B. cubensis* than in *B. plutonia* (see Key, p. 148), the thorns on its disc are relatively smaller, and usually there are only 1–2 thorns on either shoulder; the first and second dorsals (confluent in *B. plutonia*) are usually separated by a definite interspace in *B. cubensis*; the teeth average a little more numerous in *B. cubensis* than in *B. plutonia*, and the rostral cartilage is conspicuously longer, though intermediates may occur in this respect.

Description. Proportional dimensions in per cent of total length. Female, 203 mm (Harv. Mus. Comp. Zool., No. 36445), and male, 210 mm (Harv. Mus. Comp. Zool., type, No. 36443), from Cuba.

Disc: extreme breadth 46.2, 49.7; length 37.1, 39.0.
Snout length: in front of orbits 8.4, 10.0; in front of mouth 10.8, 11.0.
Orbits: horizontal diameter 4.4, 4.8; distance between 2.8, 2.9.
Spiracles: length 2.2, 2.4; distance between 6.7, 7.1.
Mouth: breadth 5.7, 6.2.
Nostrils: distance between inner ends 4.4, 5.0.
Gill openings: lengths, 1st 1.0, 1.2; 3rd 1.0, 1.2; 5th 0.7, 1.0; distance between inner ends, 1st 10.3, 11.0; 5th 6.9, 6.7.
First dorsal fin: vertical height 1.0; 1.2; length of base 4.9, 5.2.
Second dorsal fin: vertical height 1.0, 1.7; length of base 4.2, 3.8.
Pelvics: anterior margin 10.8, 11.2.
Distance: from tip of snout to center of cloaca 35.0, 38.1; from center of cloaca to 1st dorsal 50.8, 50.0; to tip of tail 65.0, 61.9; from rear end of 2nd dorsal base to tip of caudal 2.5, 1.4.
Interspace between: 1st and 2nd dorsals 3.0, 1.4.

Disc about 1.2–1.3 times as broad as long, obtusely rounded in front; tip of snout marked by a low projection; maximum anterior angle in front of spiracles 115–130°; anterior margin of disc rather strongly convex anterior to level of orbits and concave opposite spiracles in most cases, more strongly so in males but more nearly straight in some females; outer and posterior corners broadly rounded, posterior and inner

4. Atlantis Sts. 2961, 2983, 2984, 2986, 2987, 2988, 2999, 3432, 3438, 3449, 3451, 3457, 3483, and 3485; for precise localities, see Chace (Contrib. No. 274, Woods Hole oceanogr. Inst., 1940).
5. Albatross Sta. 2664.

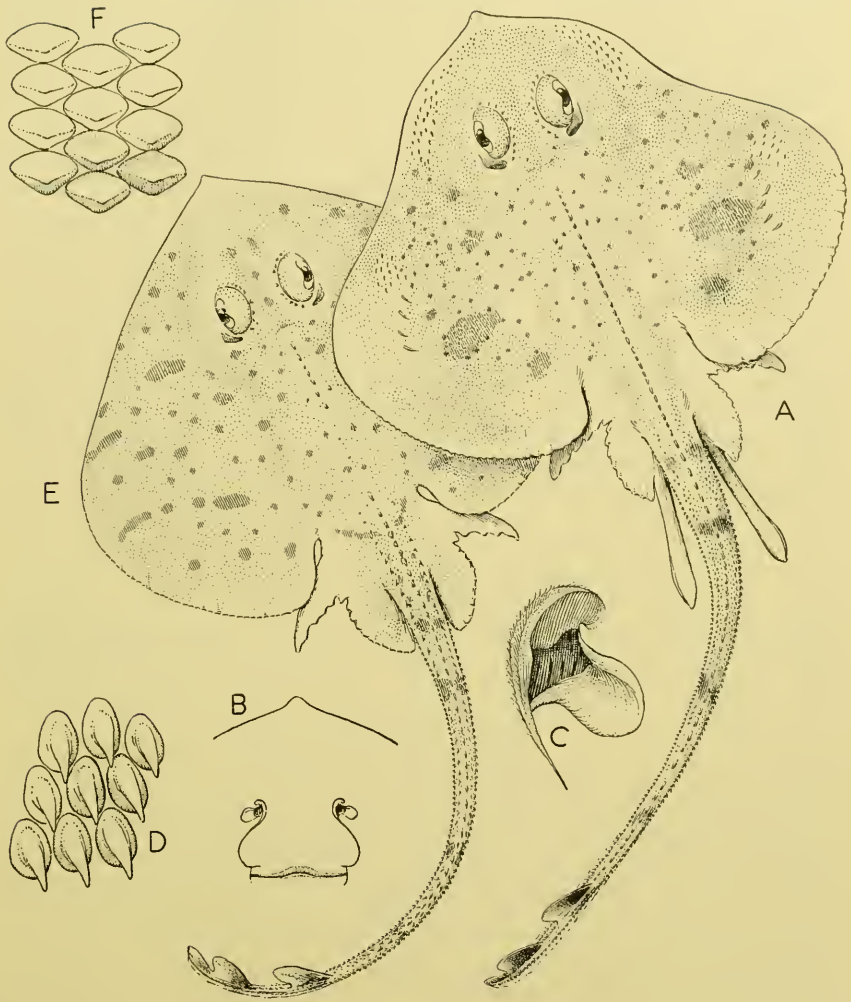


FIGURE 66. *Breviraja cubensis*. *A* Male, 210 mm long, from off Santa Clara Province, north coast of Cuba, Lat. 23°50′ N, Long. 79°51′ W, ATLANTIS St. 3451, 405 fathoms (Harv. Mus. Comp. Zool., No. 36443, type). *B* Lower surface of anterior part of head of same, to show mouth and nostrils. *C* Nostril of same, about 6.3×. *D* Upper teeth of same from near center of jaw, about 13×. *E* Female, 202 mm long, from off Santa Clara Province, north coast of Cuba, Lat. 23°11′ N, Long. 79°08′ W, 235–260 fathoms, ATLANTIS St. 2983 (Harv. Mus. Comp. Zool., No. 36364). *F* Upper teeth of same from near center of jaw, about 13×.

margins both strongly convex. Axis of greatest breadth about 75 % of distance back from snout toward axils of pectorals. Tail slender, its lateral folds narrow, confined to posterior two-thirds, broadening a little rearward; its length from center of cloaca to first dorsal about 1.3–1.4 times as great as distance from center of cloaca to snout, about 1.6–1.8 times as great to tip.

Upper surface of disc (except for tip of snout) and tail rough with small prickles on half-grown specimens and on females to maturity, but mature males smoother along a narrow marginal band and over areas of varying extent on inner parts of pectorals; both sexes with 9–15 small thorns around inner margin of orbit, the series sometimes interrupted midway; 1–2 small thorns inward from inner end of spiracle, and 1–2 on each shoulder close to midline; also a median row of 50–100 or more thorns of various sizes grading down to prickles from nuchal region to first dorsal fin, the row continuous on some specimens but more or less interrupted on others between pectoral and pelvic girdles and much more prominent on some than on others; tail posterior to axils of pelvics with 1–2 additional rows of small thorns or large prickles along either side; anterior parts of dorsals and interspace between first and second dorsals prickly; pelvics either smooth or more or less prickly along inner parts. Sexually mature males with a patch of small thorns on outer part of disc opposite orbits, their alar spines in 2–4 rows opposite outer corners of pectorals, 3–6 spines in each row. Lower surface smooth.

Snout in front of orbits 1.6–2.1 times as long as orbit, its length in front of mouth 2.1–2.6 times as great as distance between exposed nostrils. Orbit about 1.5 times as long as distance between orbits and about two times as long as spiracle. Distance between first gill openings 2.1–2.7 times as long as distance between exposed nostrils, 1.3–1.6 times between fifth gill openings; first gill openings 1.1–1.3 times as long as fifth and about 18–26 % as long as breadth of mouth. Nasal curtain and posterior (outer) margin of nostril both smooth-edged. Mouth weakly arched centrally.

Teeth $\frac{38-48}{38-48}$; close-set in quincunx, with obscure transverse cutting edge and faintly indicated cusp in young and in females to maturity, but with long and sharp recurved cusp in mature males.

Dorsals similar in shape, the base of the first equal to or slightly longer than that of the second, usually separated by an interspace 0.25–1.0 times as long as base of first dorsal but sometimes confluent. Caudal membrane posterior to second dorsal about half as long as base of second dorsal. Pelvics deeply concave outwardly in subtriangular contour, scalloped around the indentation; anterior margin about 90–100 % as long as distance from its own origin to rear tip of pelvic; anterior lobe slender, tapering to a narrowly-pointed tip, of two slender radials in addition to the first stout one; posterior lobe with moderately convex and more or less wavy outer margin, extending nearly $\frac{1}{4}$ the distance rearward from level of axils of pectorals toward first dorsal fin, the rear tip narrowly rounded on young of both sexes and on adult females but more pointed on adult males. Claspers of sexually mature males slender, reaching about $\frac{1}{3}$ the distance from axils of pelvics toward first dorsal, their tips simple.

Rostral cartilage triangular, extending about 70–75 % of the distance from front of cranium toward tip of snout.

Color. Upper surface of disc pale brown, with darker brown spots and blotches vaguely outlined and varying widely in size, number and distribution, most conspicuous on small specimens; very young ones usually with a dark curved bar extending from behind orbit to shoulder region and with a narrow crescentic darker band (concavity forward) crossing base of tail; outer posterior part of each pectoral of some adults with one dark blotch much larger than the others; anterior lobes of pelvics whitish above, the posterior lobe of same brownish hue as disc, sometimes with a few irregular dark spots; tail pale brown, usually with 5–6 crossbars vaguely outlined, more conspicuous on large specimens than on small, the two more posterior ones crossing the two dorsal fins; anterior part of caudal membrane blackish. Lower surface pale yellowish without dark markings.

Size. The smallest specimens seen (about 68 mm long) apparently were newly hatched. Males mature (as shown by their claspers) at a length of 180–210 mm. This, with the fact that the largest specimen (a female) among 70 was only 221 mm long, indicates that this Skate does not grow to a length greater than about 300 mm.

Developmental Stages. Egg cases have not been seen. Newly hatched specimens closely resemble their parents.

Habits. We know only that this is a deep-water species, so far recorded only from 235–405 fathoms.

Range. Known only off the north central coast of Cuba.

Reference:

Breviraja cubensis Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103* (7), 1950: 394 (descr., ills., depth, off N. Central Cuba).

Breviraja plutonia (Garman) 1881

Figures 62 (middle right), 67, 68

Study Material. Forty-two specimens, males and females, 132–253 mm long; one (the type) from the offing of Savannah, Georgia, Lat. 31°57′ N, Long. 78°19′ W, in 333 fathoms; the remainder trawled off Jacksonville, Florida, Lat. 30°21′ N, Long. 79°55′ W, at 230–250 fathoms, Feb. 24, 1940 (Atlantis Station 3779); all in the Harvard Museum of Comparative Zoology.

Distinctive Characters. B. plutonia falls with *B. sinus-mexicanus*, *B. atripinna* and *B. cubensis* in the long-tailed division of the genus. But it is easily separable from *B. sinus-mexicanus* by the anterior contour of its disc (cf. Fig. 67 with 69, 70). It is separated from *B. atripinna* by this same feature as well as by the fact that its first and second dorsals are confluent, and by the variegated color pattern on the upper surface of its disc. It resembles *B. cubensis* closely in shape of disc and in dermal armature, but the anterior lobes of its pelvics are considerably longer relatively; the thorns on the anterior part of its tail and on its disc are larger and more conspicuous, usually with 2–4 on

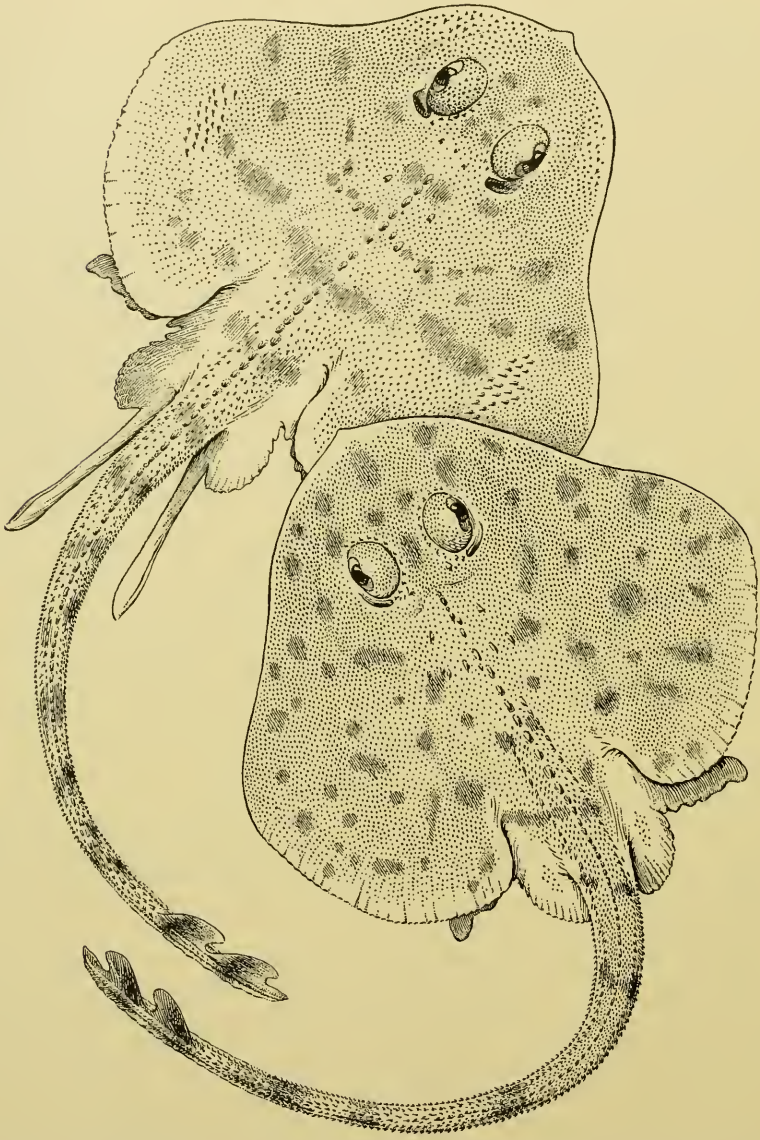


FIGURE 67. *Breviraja plutonia*, male, 230 mm long, and female, 238 mm long, from off northern Florida, Lat. 30°21′ N, Long. 79°55′ W, 230–250 fathoms, ATLANTIS St. 3779 (Harv. Mus. Comp. Zool., No. 36493).

each shoulder; its dorsal fins are confluent (usually more or less separated in *cubensis*); its teeth average slightly fewer than in *cubensis*; and its rostral cartilage is considerably shorter relatively than is usual in *cubensis* (see Fig. 62).

Description. Proportional dimensions in per cent of total length. Female, 216 mm, and male, 230 mm (Harv. Mus. Comp. Zool., No. 36493), from off Jacksonville, Florida.

Disc: extreme breadth 43.5, 44.3; length 35.7, 38.2.
Snout length: in front of orbits 7.9, 6.7; in front of mouth 8.8, 8.7.
Orbits: horizontal diameter 4.4, 5.2; distance between 3.0, 3.5.
Spiracles: length 2.3, 2.4; distance between 7.0, 7.0.
Mouth: breadth 5.1, 5.6.
Nostrils: distance between inner ends 3.9, 4.8.
Gill openings: lengths, 1st 1.3, 1.3; 3rd 1.3, 1.3; 5th 1.2, 1.1; distance between inner ends, 1st 11.3, 11.1; 5th 7.6, 5.6.
First dorsal fin: vertical height 1.4, 1.5; length of base 3.7, 4.8.
Second dorsal fin: vertical height 1.6, 1.4; length of base 3.5, 4.8.
Pelvics: anterior margin 9.3, 11.7.
Distance: from tip of snout to center of cloaca 33.3, 36.1; from center of cloaca to 1st dorsal 57.0, 51.8; to tip of tail 66.7, 63.9; from rear end of 2nd dorsal base to tip of caudal 2.5, 2.6.
Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc about 1.2 times as wide as long, broadly rounded in front; tip of snout marked by a low, blunt subtriangular projection; maximum anterior angle in front of spiracles about 130–135°; anterior margins concave abreast of spiracles, more deeply so on adult males than on females or on young; both outer and posterior corners broadly rounded; posterior margins moderately and evenly convex, inner margins weakly so. Tail with narrow lateral fold low down on each side along posterior two-fifths extending to tip; its length to first dorsal about 1.4–1.7 times as great as distance from center of cloaca to tip of snout and about 1.8–2.0 times as great to tip.

Upper surface smooth on tip of snout and around rear corners of pectorals but prickly elsewhere on disc and on tail, most densely so above eyes; orbit with two small thorns on posterior margin on small specimens and up to 12 in a continuous row around inner edge on adults; one larger thorn inward from inner end of spiracle; 2–3 on each shoulder on young, 3–4 in a transverse row on adults, these being larger and more conspicuous on females than on mature males and preceded on some by one thorn on either side in advance of shoulder; midline of back with a continuous row of larger and smaller thorns (varying considerably in number on specimens of the same size), about 45–70 from nuchal region back to about midlength of tail, followed rearward to first dorsal by thorns less regularly arranged, often interrupted and usually not in exact midline; an additional row of irregularly arranged smaller thorns on either side of the median row from pectoral girdle rearward along anterior part of tail, succeeded by 1–3 irregular rows to first dorsal and by smaller thorns or prickles to tip of tail; pelvics naked in both

sexes; anterior part of dorsals prickly; caudal membrane also with a few prickles. Maturing males developing additional small thorns along marginal belts abreast of eyes; their alar spines in 3–4 irregular rows. Lower surface smooth, except sometimes prickly along margins of anterior part of tail.

Snout in front of orbit about 1.3–1.8 times as long as orbit, its length in front of mouth about twice as great as distance between exposed nostrils. Orbit about 1.5 times

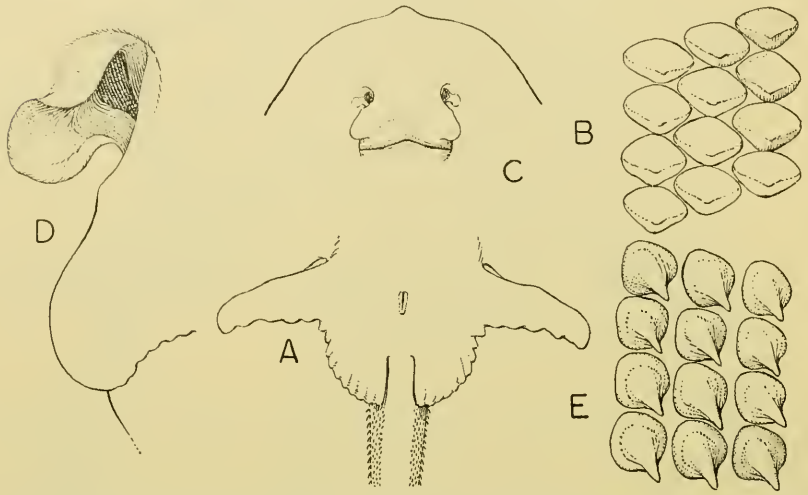


FIGURE 68. *Breviraja plutonia*. *A* Ventral view of pelvics of female pictured in Fig. 67, about 1×. *B* Upper teeth of same, about 17×. *C* Lower side of anterior part of head of male pictured in Fig. 60, about 1×. *D* Right-hand nostril and nasal curtain of same, about 5×. *E* Upper teeth of same, about 17×.

as long as distance between orbits and about 2.0 times as long as spiracle. Distance between first gill openings 2.3–2.9 times as long as distance between exposed nostrils, 1.2–1.9 times between fifth gill openings; first gill openings 1.1–1.2 times as long as fifth and about 25 % as long as breadth of mouth. Nasal curtain smooth or slightly irregular; posterior (outer) margin of nostrils smooth. Mouth only slightly arched centrally.

Teeth $\frac{32-34}{32-34}$; those of young and of adult females close-set in quincunx, with obscure transverse cutting edge and faintly indicated cusp; those of mature males loosely spaced in transverse series, with narrow conical cusps directed outward toward corners of mouth.

First and second dorsals similar in size and shape, confluent at base; caudal membrane posterior to second dorsal only about half as long as base of second dorsal. Pelvics deeply concave outwardly; anterior margin about as long as distance from its own origin

to rear tip of pelvic or a little longer; anterior lobe fleshy, narrow, with abruptly rounded tip, including four radials besides the first stout one; outer margin of posterior lobe scalloped and moderately convex; rear corner subangular, extending about 20–25 % of distance from level of axils of pectorals toward first dorsal. Claspers of mature males slender, extending rearward a little less than $^1/_3$ the distance from axils of pelvics toward tip of tail; tip of clasper with prominent blade, but otherwise simple.

Rostral cartilage narrow, blunt, extending about 60 % of distance from front of cranium toward tip of snout.

Color. Upper surface varying from pale yellowish brown to darker greyish brown, purplish brown, or mouse gray; skin at bases of prickles and at rear sides of larger thorns densely pigmented, thus producing a finely freckled appearance; disc irregularly and more or less strongly marked with dark spots or blotches, vaguely outlined and varying from specimen to specimen in size, shape, number, and arrangement; some individuals variegated in addition with a greater or lesser number of small roundish white spots irregularly distributed. Tail with 5–7 irregular dark crossbars, either continuous across upper surface or interrupted there, the two more posterior crossbars usually nearly black and crossing the first and second dorsal fins; tail on some individuals also with whitish lateral blotches, either confined to sides or meeting above; caudal membrane wholly or partly black. Lower surface yellowish white, sometimes with posterior corners of pectorals more or less dusky and with dark crossbars encroaching somewhat onto lower surface from sides of tail.

Size. Males may mature sexually at a length no greater than about 230 mm to judge from the length of claspers (Fig. 67). The largest specimen seen (a female, the type) is 253 mm long.

Developmental Stages. The egg cases have not been seen.

Habits. The depths of capture (230–333 fath.) mark this as a deep-water species; nothing else is known of its habits.

Range. Thus far *B. plutonia* has been taken only on the continental slope in the offings of Georgia and South Carolina, where the original specimens were trawled by the Blake in 1880,[6] off northern North Carolina, where it has been taken by the winter trawl fishery, and in the offing of Jacksonville, Florida (see Study Material, p. 297).[7]

Synonyms and References:

Raja[8] *plutonia* Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 236 (descr., meas., depth, off S. Carolina and Georgia); Goode and Bean, Bull. Mus. comp. Zool. Harv., *10*, 1883: 225 (listed after Garman, 1881); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 878 (descr., after Garman, 1881); True,

6. Blake Sts. 316, 317, 321; Lat. 31°57′ N, Long. 78°19′ W; Lat. 32°07′ N, Long. 78°38′ W; Lat. 32°43′ N, Long. 77°21′ W.

7. *Raia plutonia* Barnard 1925 (Ann. S. Afr. Mus., *21* [1], 1925: 68) from South Africa, earlier described as *R. albalinea* by von Bonde and Swart (Fish. Mar. biol. Surv. S. Afr., Rep. 3 [1922], Spec. Rep. 5, 1924: 6, pl. 20, fig. 1), differs noticeably from *Breviraja plutonia* of the western Atlantic in its considerably shorter tail, in larger and fewer thorns around the eyes, and in its pale dorsals. It has been identified provisionally by Norman (Discovery Rep., *12*, 1935: 46) with *Raia spinacidermis* Barnard 1923 (Ann. S. Afr. Mus., *13* [8]: 440), which appears to be closest to the European *Raja fullonica* Linnaeus 1758.

8. Sometimes spelled *Raia*.

List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 261 (listed, S. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (listed: Deep Sea Fauna); Günther, Challenger Rep., *22*, 1887: 10 (descr., locals., after Garman, 1881); Goode and Bean, Smithson. Contr. Knowl., *30*, *31* (Atlas), 1895: 27, pl. 8, fig. 26; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 27, pl. 8, fig. 26 (descr., locals., after Garman, 1881, ill.); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 69 (descr., off S. Carolina); Rep. U. S. Comm. Fish. (1895), 1896: 221 (listed off S. Carolina); Garman, Mem. Harv. Mus. comp. Zool., *24*, 1899: 380 (range, depth); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 102 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 335, pl. 18, fig. 1 (refs., descr., ill., depth, off S. Carolina); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 26 (listed, off S. Carolina); Pearson, Invest. Rep. U. S. Bur. Fish., 10 (1), 1932: 18 (off north. N. Carolina, winter).

Malacorhina plutonia Garman, Bull. Mus. comp. Zool. Harv., *8*, 1881: 237 (subgen. *Malacorhina* proposed).

Probable Synonym:

Raja acanthiderma Fowler, Fish Culturist, *26*, 1947: 73; Notul. Nat. Acad. nat. Sci. Philad., 199, 1947: 14, ftn. (descr., ill., Gulf Stream off Florida).

Breviraja sinus-mexicanus Bigelow and Schroeder 1950

Figures 62 (lower right), 69, 70

Study Material. Ninety-four specimens,[9] males and females (including type), 117 to 355 mm long, from the northeastern part of the Gulf of Mexico between the offings of Pensacola and of the Mississippi River Delta, in 170 to 347 fathoms, all in the U. S. National Museum and the Harvard Museum of Comparative Zoology.

Distinctive Characters. The shortness of its rostral cartilage separates *B. sinus-mexicanus* from all Skates of the genus *Raja*. Within its own genus it falls with *B. atripinna* and the *B. cubensis*-and-*plutonia* group in the great length of its tail. But it is distinguishable from young *B. atripinna* by the thorniness of its tail and from older ones by the shortness of the interspace between its two dorsal fins (cf. Figs. 69, 70 with 63) and by the pale coloration of the dorsals. Its tail is so much thornier than that of the *B. cubensis*-and-*plutonia* group that there is no danger of confusing it with either of these, and its anterior angle is less obtuse.

Description. Proportional dimensions in per cent of total length. Female, 228 mm long, the type (U. S. Nat. Mus., No. 103376), and male, 321 mm long (U. S. Nat. Mus., No. 148275), from the Gulf of Mexico.

Disc: extreme breadth 44.7, 48.0; length 39.4, 40.0.

Snout length: in front of orbits 9.4, 10.0; in front of mouth 11.4, 11.6.

Orbits: horizontal diameter 3.5, 3.9; distance between 2.6, 3.0.

Spiracles: length 2.2, 2.5; distance between 5.9, 6.5.

Mouth: breadth 4.6, 5.0.

Nostrils: distance between inner ends 4.6, 4.8.

9. Albatross Sta. 2396 in Lat. 28°34′ N, Long. 86°48′ W; Sta. 2395 in Lat. 28°36′ N, Long. 86°50′ W; Sta. 2398 in Lat. 28°45′ N, Long. 86°26′ W; Sta. 2377 in Lat. 29°08′ N, Long. 88°08′ W; Oregon Sta. 307 in Lat. 29°00′ N, Long. 88°35′ W and Sta. 319 in Lat. 29°20′ N, Long. 87°25′ W, and Oregon Sts. 62, 351, 472, 476, 481, 489, 490, and 500 in the same general region.

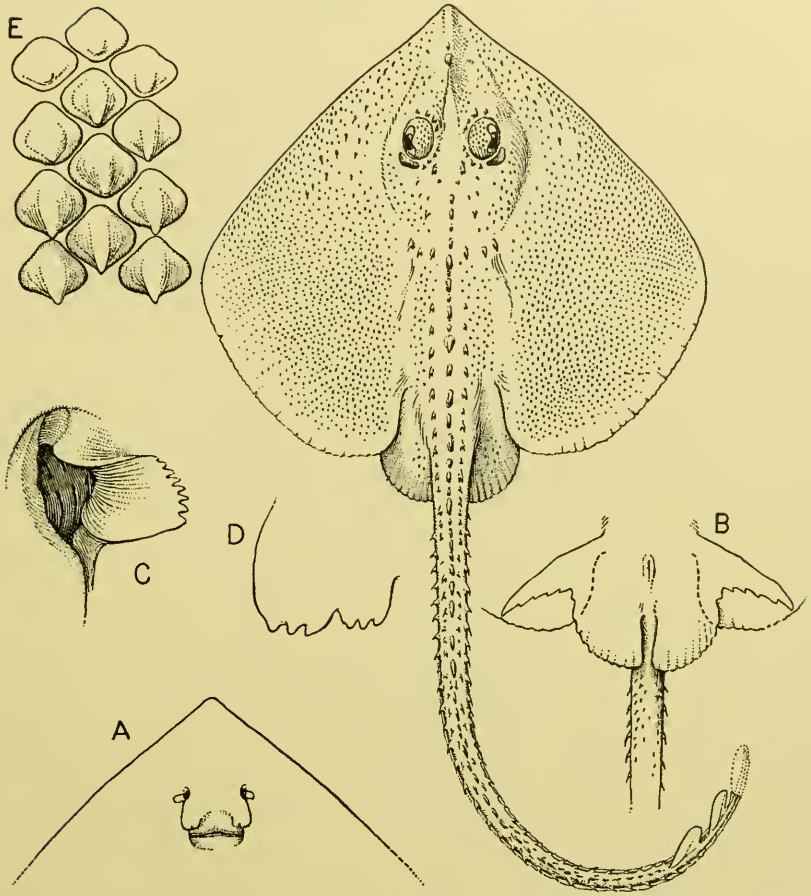


FIGURE 69. *Breviraja sinus-mexicanus*, female, 228 mm long, from off Pensacola, Florida (U. S. Nat. Mus., No. 103376, type). *A* Lower side of anterior part of head. *B* Ventral view of pelvics and base of tail. *C* Left-hand nostril, about 14×. *D* Margin of right-hand nasal curtain, about 9.2×. *E* Upper teeth, about 23×.

Gill openings: lengths, 1st 0.9, 1.2; 3rd 0.9, 1.2; 5th 0.8, 0.6; distance between inner ends, 1st 11.0, 10.0; 5th 6.2, 5.0.
First dorsal fin: vertical height 1.3, 1.6; length of base 3.5, 3.7.
Second dorsal fin: vertical height 1.3, 1.6; length of base 2.6, 3.7.
Pelvics: anterior margin 10.5, 10.3.
Distance: from tip of snout to center of cloaca 32.9, 35.5; from center of cloaca

to 1st dorsal 54.8, 51.5; to tip of tail 67.1, 64.5; from rear end of 2nd dorsal base to tip of caudal –, 4.1.

Interspace between: 1st and 2nd dorsals 0.9, 0.6.

Disc about 1.1–1.2 times as broad as long; snout angular, blunted at tip; maximum anterior angle in front of spiracles about 100–110°; anterior margins nearly straight anterior to level of orbits, weakly convex thence outward on females but rather conspicuously concave at general level of spiracles on mature males, and tip of snout more prominent; outer and posterior corners broadly rounded; posterior margin evenly and rather strongly convex and inner margin weakly convex to axil. Axis of greatest breadth about 72 % of distance rearward from snout toward axils of pectorals. Tail from center of cloaca to first dorsal about 1.5–1.7 times as long as distance from center of cloaca to snout and about twice as long to tip; its lateral folds narrow, extending entire length from close posterior to tips of pelvics and widening a little rearward.

Upper surface of disc roughened with small, sharp, movable spines except on posterior margins and along mid-dorsal belt, most of them covered with skin; skin above eyes finely prickly; two small thorns over tip of rostral cartilage on youngest, three small and one large on half-grown specimens; none on tip on adults, but there is a cluster a little rearward; about 7–11 of various sizes around inner margin of orbit on adults, either in continuous row or interrupted midway; one large thorn inward from inner end of spiracle; a patch of 8–12 scattered outward from each eye on half-grown specimens, increasing in number and size and spreading by maturity over the marginal belt as a whole anterior to level of spiracles; at first two, later 3–5, large thorns on each shoulder; midline of back with a continuous row of 11–14 thorns from nuchal region to pelvic girdle, larger ones alternating with smaller at first but later all about equal in size, followed by about 45–50 along tail to first dorsal, decreasing in size rearward and in regularity of arrangement;[10] the midrow flanked on either side by one irregular additional row from a little behind pectoral girdle to base of tail and by 1–2 such rows thence rearward past dorsals; central and posterior parts of pelvics with a few small prickles, also upper parts of dorsals; caudal membrane smooth. Mature males with thorns of mid-dorsal belt of disc somewhat fewer, smaller, and in less regular linear arrangement than on females; also outer corners of pectorals strewn with small thorns which are not present on females; alar spines about 12–20, directed rearward-inward, irregularly arranged, not conspicuous. Lower surface smooth except sometimes a few small spinelets along outer edges of tail close behind tips of pelvics, and a few small scattered prickles along its anterior one-sixth.

Snout in front of orbits about 2.6 times as long as orbit, its length in front of mouth about 2.1 times as great as distance between exposed nostrils. Orbit about 1.3 times as long as distance between orbits and about 1.6 times as long as spiracle. Distance between first gill openings 2.1–2.4 times as long as distance between exposed nostrils, 1.3–1.4 times between fifth gill openings; first gill openings 1.1–2.0 times as

10. Counting is difficult along the tail.

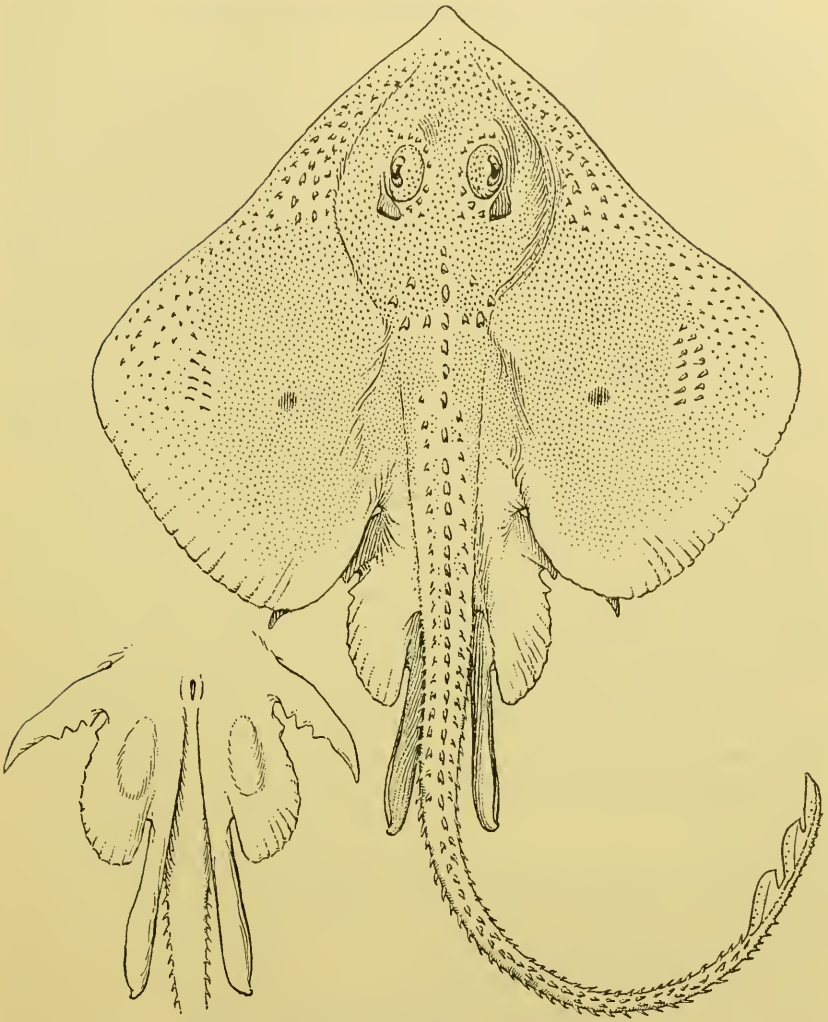


FIGURE 70. *Breviraja sinus-mexicanus*, male, about 321 mm long, from Gulf of Mexico off Mississippi River delta (U. S. Nat. Mus., No. 148275).

long as fifth and about $^1/_5$ as long as breadth of mouth. Nasal curtain more or less jagged, posterior (outer) margin of nostril more or less definitely fringed. Mouth nearly straight in females, more arched centrally in mature males.

Teeth $\frac{40-46}{36-42}$; close-set in quincunx in females, mostly with low blunt cusp, but cusp lacking on some near corners of mouth; those of adult males in transverse series and with sharp conical cusp.

Dorsals similar in shape; either confluent or with interspace up to about $^1/_3$ as long as base of first dorsal; interspace with one or two thorns; base of first dorsal about 1.0–1.3 times as long as base of second. Caudal membrane posterior to second dorsal about 1.3–1.4 times as long as base of second dorsal. Pelvics deeply concave outwardly, scalloped around indentation; anterior margin about 88 % as long as distance from pelvic origin to rear tip; anterior lobe narrowing to slightly blunted tip, with four slender radials besides first stout one; outer margin of posterior lobe strongly convex and weakly scalloped; rear corner abrupt, reaching back about $^1/_5$ of distance from level of axils of pectorals toward first dorsal. Claspers of adult male slender, widening a little toward tips, extending rearward about $^1/_3$ of distance from axils of pelvics toward first dorsal; no terminal spines exposed when not in function.

Rostral cartilage narrowly triangular, its tip reaching a little more than halfway from front of cranium toward tip of snout. Anterior rays of pectorals reaching about halfway between level of tip of rostral cartilage and tip of snout.

Color. Upper surface brownish purple, palest on either side of rostral ridge, along edges of pectorals, and on pelvics; either plain-colored[11] or irregularly marked with small slightly darker blotches, indistinctly outlined, the most conspicuous being one to four on each side, close to base of tail[12] and midway out on disc anterior to pelvic girdle.[13] Skin over prickles of small females and juvenile males much more deeply pigmented, thus producing a dark speckled appearance; only scattered prickles so pigmented on mature specimens. Lower surface plain yellowish white, but darker hue of upper surface showing through along outer edges of pectorals.

Size. Males are mature at a length of 310–335 mm, and the presence of large thorns on the malar regions of the head of a female 325 mm long suggests that this species does not grow to a length greater than about 375 mm.

Developmental Stages. The egg cases have not been seen.

Habits. Seemingly this is a deep-water species. The stomach of one contained the remains of fish.

Range. Known only from the northern and northeastern part of the Gulf of Mexico, at the localities and depths listed under Study Material (p. 302).

Reference:

Breviraja sinus-mexicanus Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103* (7), 1950: 396 (descr., ills., Gulf of Mexico, off Pensacola, Florida).

Breviraja spinosa Bigelow and Schroeder 1950

Figures 62 (lower left), 71

Study Material. Female, 280 mm long, from off mid-Florida, Lat. 29°41′ N, Long. 79°55′ W, in 373 fathoms, taken at Albatross St. 2664, in U. S. National Museum;

11. One adult female is plain-colored.
12. This is the case on a half-grown female.
13. An adult male shows this pattern.

two females, 187 and 288 mm long (including the type), from offing of Jacksonville, Florida, Lat. 30°21′ N, Long. 79°55′ W, and Lat. 30°58′ N, Long. 79°34′ W, in 290 fathoms, collected by the Atlantis, in Harvard Museum of Comparative Zoology; also four females, probably this species, the largest about 220 mm long, taken on the continental slope in the offings of North Carolina and Delaware Bay, in 727 and 258 fathoms, in U. S. National Museum.[14]

Distinctive Characters. The presence of three or more irregular rows of large and conspicuous thorns along the midbelt of its disc marks this species off from all other western Atlantic soft-nosed Skates (genera *Breviraja*, *Psammobatis*) except *B. yucatanensis*. It is separable from the latter in that it has more conspicuous thorns, its snout anterior to the orbits is not more than about twice as long as the distance between the orbits, its first and second dorsal fins are confluent at the base, and the upper surface of its disc is not closely freckled with small dark dots.

Description. Proportional dimensions in per cent of total length. Females, 187 and 288 mm long (type), from the offing of Jacksonville, Florida (Harv. Mus. Comp. Zool., Nos. 36369, 36373).

Disc: extreme breadth 47.7, 50.8; length 41.2, 42.8.
Snout length: in front of orbits 8.0, 8.0; in front of mouth 9.1, 10.2.
Orbits: horizontal diameter 5.6, 4.8; distance between 3.2, 3.6.
Spiracles: length 3.7, 3.4; distance between 6.9, 7.0.
Mouth: breadth 6.4, 7.8.
Exposed Nostrils: distance between inner ends 5.3, 6.0.
Gill openings: lengths, 1st 1.6, 1.4; 3rd 1.6, 1.4; 5th 1.5, 1.2; distance between inner ends, 1st 14.2, 15.9; 5th 8.3, 7.9.
First dorsal fin: vertical height 1.9, 1.4; length of base 5.4, 5.8.
Second dorsal fin: vertical height 1.6, 1.5; length of base 5.4, 5.5.
Pelvics: anterior margin 10.7, 11.6.
Distance: from tip of snout to center of cloaca 39.0, 42.3; from center of cloaca to 1st dorsal 48.1, 44.4; to tip of tail 61.0, 57.7; from rear end of 2nd dorsal base to tip of caudal 2.1, 2.0.
Interspace between: 1st and 2nd dorsals 0.0, 0.0.

Disc about 1.2–1.3 times as broad as long, obtusely rounded in front; tip of snout blunt at apex and projecting little if at all; maximum anterior angle in front of spiracles about 135–140°; anterior margins convex to level of orbit, thence nearly straight to broadly rounded outer corners, the contour continuing in an unbroken arc around the convex posterior margin and broadly rounded posterior corners to axils of pectorals. Axis of greatest breadth 70–75 % of distance back from tip of snout toward axils of pectorals. Tail moderately robust, decreasing in relative length with growth; distance from center of cloaca to first dorsal about 1.3 times as great as distance from center of cloaca to tip of snout on young, about 1.1 times on larger specimens; extreme length

14. Albatross Sts. 2624 and 2730; these specimens are in poor condition.

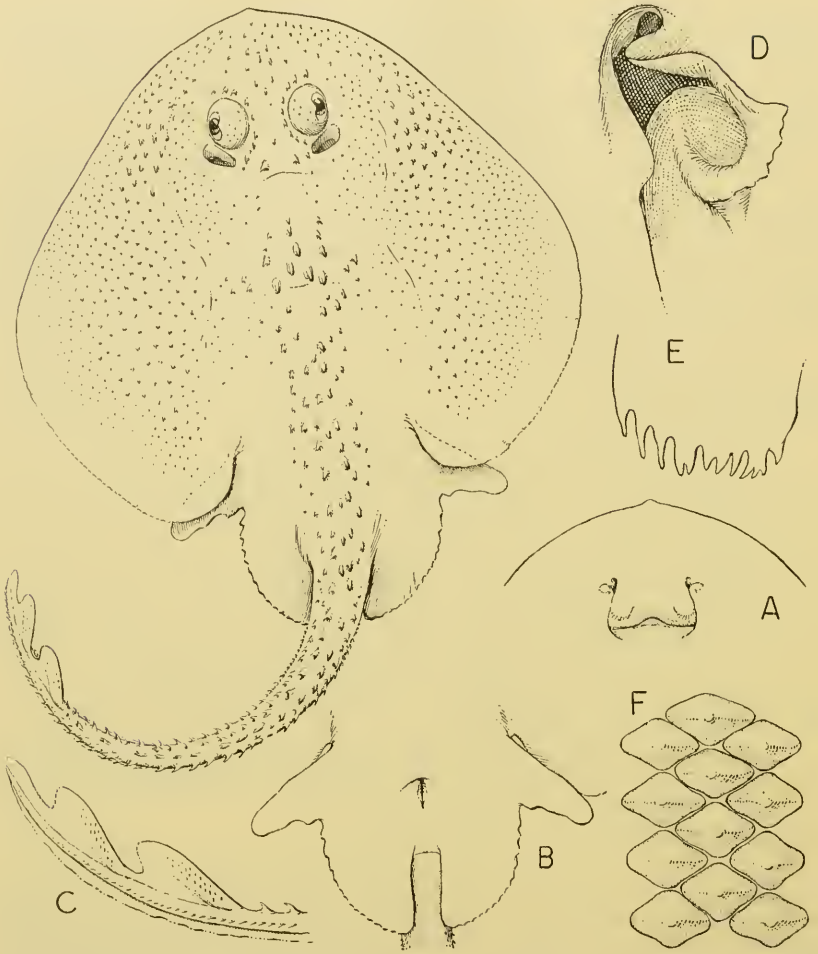


FIGURE 71. *Breviraja spinosa*, female, 288 mm long, from off northern Florida, Lat. 30°58′ N, Long. 79°34′ W, ATLANTIS St. 3781, 250–290 fathoms (Harv. Mus. Comp. Zool., No. 36373, type). *A* Lower surface of mid-anterior part of head. *B* Ventral view of pelvics. *C* Side view of posterior part of tail, about 1.2×. *D* Left-hand nostril, about 6.4×. *E* Margin of right-hand nasal curtain, about 6.4×. *F* Upper teeth, about 12×.

of tail from center of cloaca about 1.6 times as great as distance from cloaca to snout on young, about 1.4 times on larger; the lateral folds narrow, confined to posterior third of tail.

Upper surface of disc conspicuously rough; medium-sized thorns scattered along rostral ridge; about 10 around anterior and inner margins of orbit on largest specimen, fewer on smaller, sometimes one large thorn close in front of orbit;[15] one to two large thorns inward from spiracle; a few small thornlets in space between eyes on small specimens; a patch of 12–15 conspicuous thorns near outer margin abreast of eye and spiracle; 1–3 conspicuous thorns on midline in nuchal region; inner parts of pectorals with many moderate-sized thorns irregularly distributed, progressively smaller outward, posterior margins of pectorals smooth; 2–3 large thorns on each shoulder; also a band of thorns of various sizes along midbelt of back from nuchal region rearward, irregularly scattered to anterior part of tail but arranged partially in 3–5 rows back along tail to first dorsal, and successively smaller along rear half of tail, followed by 1–2 rows of smaller ones along either side of tail to tip; thorns on disc and some of those on tail large and their bases conspicuously radiate. Some small specimens lacking the pair of thorns between the spiracles, but with thorns more numerous along midbelt of disc and more nearly linear in arrangement, including a definite median row of about 25 along tail, besides 1–2 less regular rows along either side of tail. Disc as a whole (except above body cavity and around posterior margins of pectorals) further roughened by prickles of various sizes, these more numerous on small specimens than on large; skin above eyes with a few small prickles on large specimens, more prickly on smaller ones; each side of tail with a band of close-set prickles extending along anterior two-thirds on young but confined to anterior third of tail on larger specimens, followed rearward by scattered small thornlets; space between orbits more prickly on young than on adults; anterior parts of dorsals prickly, decreasingly so with growth; caudal membrane with a few scattered prickles; pelvics smooth. Alar thorns of adult male not seen. Lower surface smooth, except sometimes with a few small spines along edges of tail abreast of posterior lobes of pelvics.[16]

Snout in front of orbits about 1.5–1.7 times as long as orbit, its length in front of mouth about 1.5–1.7 times as great as distance between exposed nostrils. Orbit about 1.3–1.7 times as long as distance between orbits and about 1.5 times as long as spiracle. Distance between first gill openings 2.3–2.7 times as long as distance between exposed nostrils; between fifth gill openings 1.3–1.5 times; first gill openings 1.0–1.5 times as long as fifth and about 18–27 % as long as breadth of mouth. Nasal curtain fringed, posterior (outer) margin of nostril either fringed or only somewhat irregular. Mouth weakly arched centrally.

Teeth $\frac{36-46}{36-44}$ on specimens seen, perhaps more numerous on adults; those of females close-set in quincunx, the older rows worn smooth, the younger with low triangular cusp; teeth of adult male not seen.

First and second dorsals similar in size and shape, confluent at base, their upper margins noticeably sloping, their posterior margins slightly recurved. Caudal membrane posterior to second dorsal a little less than half as long as base of second dorsal.

15. This is true of one of the fragmentary specimens from the offing of Delaware Bay; see Study Material, p. 307.
16. On our larger specimen one side of the tail but not the other has these spines.

Pelvics deeply concave outwardly in subtriangular contour, weakly scalloped around the indentation; anterior margin about 65–70 % as long as distance from pelvic origins to rear tips of pelvics; anterior lobe small and fleshy with well rounded tip and three radials besides the first stout one; posterior lobe rather strongly convex outwardly, its rear corners abruptly rounded and reaching back a little less than 1/5 of distance from level of axils of pelvics toward first dorsal. Claspers of mature males not seen.

Rostral cartilage triangular, extending about half the distance from front of cranium toward tip of snout. Anterior rays of pectorals reaching close to tip of snout, not far apart there.

Color. Upper surface light brown, the disc either plain or indistinctly marked with a few whitish blotches, larger and smaller, arranged symmetrically on either side of median line; anterior parts of dorsals and tip of caudal membrane brownish; some specimens with lower surface either plain whitish (including one of the larger specimens) or pale brownish (after many years in alcohol), but others with dark brown blotches developing inward from each nostril; central part of disc and anterior parts of pelvics of some also becoming more or less washed or blotched with sooty brown.

Remarks. The only ALBATROSS specimen that is still in adequate condition differs from the type specimen (taken off Jacksonville, Florida) in having one large thorn close in front of each orbit, fewer small thorns along the inner margins of the orbits, the mid-dorsal thorns somewhat more conspicous, and the rostral cartilage perhaps a little longer and narrower relatively. But these divergences do not seem wider than can be explained on the basis of individual or local variation, to judge from conditions among better known Skates.

Size. The size at maturity is not known.

Developmental Stages. The egg cases have not been seen.

Habits. Seemingly this is a deep-water species, the few specimens taken thus far having been trawled at 250, 258, 373 and 727 fathoms.

Range. Known only from off middle and northern Florida, off North Carolina, and off Delaware Bay, a total of seven specimens (see Study Material, p. 306).

Reference:

Breviraja spinosa Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103* (7), 1950: 400 (descr., ill., off Jacksonville, Florida).

Breviraja yucatanensis Bigelow and Schroeder 1950

Figure 72

Study Material. Juvenile male (type), 215 mm long, from notheastern slope of Yucatán, in 231 fathoms, in U. S. National Museum.

Distinctive Characters. This newly discovered species is marked off from all other known members of its genus in the western Atlantic, except for *B. spinosa*, by the presence of two or more irregular rows of thorns along the median belt of its disc rearward from the scapular region. It differs from *B. spinosa* in having less conspicuous

thorns, snout anterior to the orbits about 3.5 times as long as the distance between the orbits (not more than 2 times in *B. spinosa*), first and second dorsal fins separated by a definite (though short) interspace with one or two thorns, and in having the upper surface of its disc closely freckled with small dark brown dots (not freckled on *B. spinosa*).

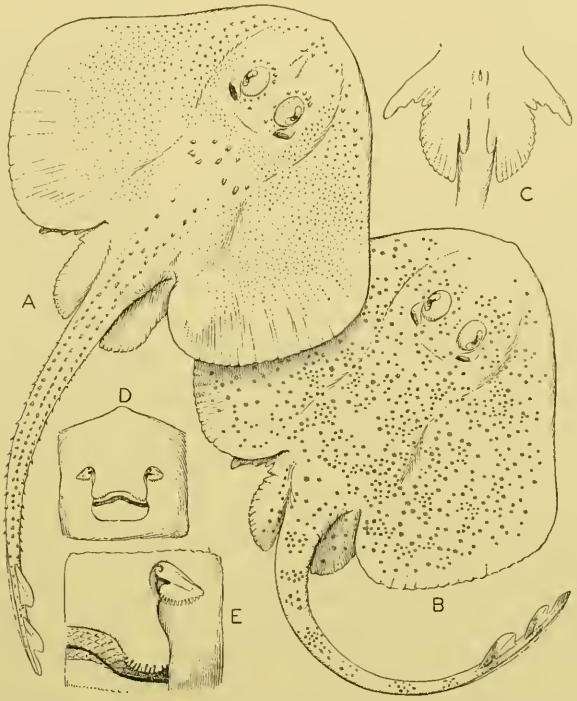


FIGURE 72. *Breviraja yucatanensis*, juvenile male, 215 mm long, type, from northeast slope of Yucatán (U. S. Nat. Mus., No. 148273). *A* Dorsal view to show thorns and prickles. *B* Same to show color pattern, without thorns and prickles. *C* Pelvic fins, ventral view. *D* Ventral view of midanterior part of head. *E* Part of same to show fringed nasal curtain and margin of nostril. *A–D*, about 0.9×; *E* about 2.7×.

Description. Proportional dimensions in per cent of total length. Male, 215 mm long, from Lat. 20°19′ N, Long. 87°04′ W (U. S. Nat. Mus., type, No. 148273).

Disc: extreme breadth 55.0; length 45.2.

Snout length: in front of orbits 9.8; in front of mouth 11.6.

Orbits: horizontal diameter 4.9; distance between 2.8.

Spiracles: length 2.6; distance between 6.5.
Mouth: breadth 6.7.
Exposed nostrils: distance between inner ends 7.0.
Gill openings: lengths, 1st 1.4; 3rd 1.9; 5th 1.3; distance between inner ends, 1st 13.2; 5th 8.1.
First dorsal fin: vertical height 2.3; length of base 5.8.
Second dorsal fin: vertical height 2.1; length of base 4.9.
Pelvics: anterior margin 12.6.
Distance: from tip of snout to center of cloaca 39.5; from center of cloaca to 1st dorsal 44.7; to tip of tail 60.5; from rear end of 2nd dorsal base to tip of tail 3.7.
Interspace between: 1st and 2nd dorsals 1.4.

Disc about 1.2 times as broad as long, moderately obtuse in front, tip of snout hardly protruding; maximum anterior angle in front of spiracles about 128°; anterior margins weakly convex from tip of snout to level of eyes, slightly concave at level of spiracles and straight thence outwardly; outer corners broadly rounded; posterior margins weakly and evenly convex; posterior corners broadly rounded, their curvature continuous to axils of pectorals. Lateral folds on tail extremely narrow, extending along posterior four-fifths nearly to tip. Tail from center of cloaca to first dorsal about 1.1 times as long as distance from center of cloaca to tip of snout, and about 1.5 times as long to tip. Distance from axils of pelvics to first dorsal about as long (1.1) as distance from axils of pelvics to fronts of orbits, about 90 % as long as distance from center of cloaca to tip of snout.

A few small thorns on anterior part of rostral ridge; 5–7 along inner anterior margin of orbit;[17] 1–2 on inner margin of orbit and a group of about four between inner posterior edge of orbit and inner end of spiracle; about three on nuchal region; 2–3 on each shoulder; two rows along mid-dorsal belt of disc from a little behind pectoral girdle rearward, with an occasional thorn between them in the midline; outer anterior parts of pectorals sparsely strewn with small thorns grading down to prickles; inner parts of pectorals as well as nuchal region roughened generally with minute prickles; a few prickles here and there on anterior part of head, between thorns on shoulders and along mid-dorsal belt; skin over eyes prickly; posterior parts of pectorals smooth. Upper surface of tail with 3–4 irregular rows of thorns along anterior part, these about as large as those on disc, decreasing to 2–3 rows rearward to first dorsal fin; one thorn in interspace between first and second dorsals; each side of tail (from axil of pelvic) with a band of close-set prickles along anterior half, decreasing in number posteriorly to 1–2 rows interspaced with small thornlets past second dorsal fin; dorsal fins and upper surface of pelvics smooth. Lower surface smooth everywhere.

Snout in front of orbits about 3.5 times as long as distance between orbits, its length in front of mouth about 1.6 times as great as distance between exposed nostrils.

17. Five on one side and seven on the other on specimen examined.

Orbit about 1.7 times as long as distance between orbits and 2.2 times as long as spiracle. Distance between first pair of gill openings about 1.9 times as great as distance between exposed nostrils, about 1.2 times between fifth gills; first gills about 1.3 times as long as fifth gills and 21 % as long as breadth of mouth. Nasal curtain, as well as expanded outer (posterior) margin of nostril, fringed. Mouth arched only a little forward in juveniles and probably in females, perhaps more strongly so in adult males.

Teeth 46 in upper jaw; those of juvenile males (probably those of females also) oval, rounded, without cusp, close-set in quincunx; those of mature males not seen.

First and second dorsals about alike in size and shape, the anterior margins sloping and weakly convex, the posterior margins slightly recurved; dorsal fins separated by a short but definite interspace with one thorn. Caudal membrane posterior to second dorsal about 30 % as long as base of first dorsal. Pelvics deeply concave outwardly, with three conspicuous scallops at base of concavity; anterior margin about 60 % as long as distance from pelvic origin to rear tip; anterior lobe fleshy with rounded tip; posterior lobe weakly and evenly convex outwardly, rear tip narrowly blunted, reaching about $^1/_5$ of distance from axils of pelvics toward first dorsal fin. Claspers of mature males not seen.

Rostral cartilage extends a little more than $^2/_3$ (69–70 %) of distance from front of cranium toward tip of snout. Anterior radials of pectorals extend nearly to level of tip of snout.

Color. Upper surface (after many years in alcohol) brownish gray; disc and anterior part of tail thickly freckled with darker brown dots; posterior part of tail with similar dots aggregated in two indistinct crossbars; also an additional more definite dark bar crossing tail and anterior part of each dorsal fin; caudal membrane sooty. Lower surface uniformly pale yellowish.

Size. A male (only specimen known), 215 mm long, is juvenile, its claspers reaching only about halfway along inner margins of pelvics. Size at maturity not known.

Habits. The depth of capture (231 fath.) of the only recorded specimen suggests that this is a deep-water species, but nothing definite is known of its habits.

Range. So far known only from the slope off northeastern Yucatán, in 231 fathoms.[18]

Reference:

Breviraja yucatanensis Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103* (7), 1950: 402 (descr., ill., off Yucatán).

Genus *Cruriraja* Bigelow and Schroeder 1948

Cruriraja Bigelow and Schroeder, J. Mar. Res., 7 (3), 1948: 549; type species, *C. atlantis* Bigelow and Schroeder. Off north coast of Cuba.

Generic Synonyms:

Raia (in part) von Bonde and Swart, Fish. Mar. biol. Surv. S. Afr., Rep. 3 (1922), Spec. Rep. 5, 1924: 9, 11, pl. 21, fig. 2, pl. 22, fig. 1, for *R. parcomaculata* and *R. durbanensis* von Bonde and Swart 1924. South Africa. Not *Raja* Linnaeus 1758.

18. Albatross Sta. 2359, Lat. 20°19′ N, Long. 87°04′ W, January 29, 1885.

Generic Characters. Rajidae with pectorals of ordinary form, without spatula-like lateral processes. The outer margins of the pelvics are so deeply notched that the anterior division, which arises independently from the lower surface of the disc some distance inward from the edge of the latter, is entirely cut off from the remainder of the fin as a separate limb-like structure. The two or three radial cartilages that are ordinarily borne near the anterior end of the basipterygial cartilage are lacking, and the gap resulting from their absence corresponds in position to the gap seen externally between the anterior and posterior subdivision of the pelvic fin. Anterior subdivision of pelvics slender, subcylindrical, tapering toward tip, stiff proximally but softer distally, consisting of three articulated segments and hence flexible at two or three points as well as at its base (stoutness of musculature toward its base suggests considerable powers of movement); its support is maintained by the first stout radial and two or three slender radials which are articulated directly to the outer extremity of the pelvis. Posterior lobe of pelvics finlike, supported by about 18 radials. Rostral cartilage rigid, narrow, extending nearly or quite to tip of snout. Tips of anterior pectoral rays falling well short of tip of rostral cartilage. Characters otherwise as in *Raja*.

Remarks. The limb-like modification of the anterior subdivisions of the pelvics of *Cruriraja* is the outstanding feature of the genus. In this respect it appears to be unique among batoids so far as is known, except for the little-known genus *Anacanthobatis* von Bonde and Swart 1924,[19] from Natal, in which the anterior subdivisions of the pelvics are described as "leg-like" and "segmented" (as in *Springeria*, p. 328), and except for one genus of Electric Rays (*Typhlonarke*), family Narkidae. The function of the pelvic limbs is not known; they may be tactile, as are the feeler-like ventrals of the hakes (*Urophycis*), or they may assist in the progress of their owners over the bottom.

Size. The two known species from the Atlantic are small, males having large and fully developed claspers at lengths no greater than 300–325 mm. But the maximum size of the Indian Ocean representatives is not known, for no mature specimens were included among the few that have been seen.

Habits and Range. Nothing whatever is known of the life histories of the members of the genus, except that they are confined to moderately deep water, the recorded depths of capture ranging from 280–425 fathoms for the Atlantic (p. 319) and from 298–470 fathoms off the Natal Coast.

Key to Species[20]

1a. Interspace between first and second dorsals about 1.5 times as long as base of first dorsal. *atlantis* Bigelow and Schroeder 1948, p. 315.

1b. Interspace between first and second dorsals not more than about half as long as base of first dorsal.

19. Fish. Mar. biol. Surv. S. Afr., Rep. 3 (1922), Spec. Rep. 5, 1924: 18, pl. 23.

20. *Raja andamanica* Lloyd 1909 (Mem. Indian Mus., *2* [3], 1909: 140; Ill. Zool. Investigator, Fishes, 10, 1909: pl. 46, fig. 2) may prove to be a *Cruriraja* also, when the nature of its pelvic fins is known definitely.

2a. No large thorns along midline of back between levels of spiracles and of outer corners of pectorals, or on shoulder regions; upper surface without small prickles except close along outer anterior margins.

poeyi Bigelow and Schroeder 1948, p. 319.

2b. Midline of back with an unbroken line of large thorns from nuchal region back onto tail; upper surface partly or entirely roughened with smaller prickles in addition to the larger thorns.

3a. A group of thorns on tip of snout and others along anterior half of rostral ridge; two thorns in interspace between dorsal fins.

parcomaculata (von Bonde and Swart) 1924.[21]
Off Natal Coast, South Africa.

3b. No thorns on tip of snout, along anterior half of rostral ridge, or in interspace between dorsal fins. *durbanensis* (von Bonde and Swart) 1924.[22]
Off Natal Coast, South Africa.

Cruriraja atlantis Bigelow and Schroeder 1948

Figures 73, 74

Study Material. Thirteen specimens, male and female, 100–332 mm long, including the type (No. 36320), trawled by the ATLANTIS off Havana and the north central coast of Cuba, in the Harvard Museum of Comparative Zoology.

Distinctive Characters. Except for its genus mates *C. poeyi*, *C. parcomaculata* and *C. durbanensis*, *C. atlantis* is separable from all other known members of the family Rajidae by the complete subdivision of its pelvic fins. And the great width of the interspace between its first and second dorsal fins marks it off from its three genus mates. The fact that the upper surface of its disc is about uniformly covered with small prickles further separates it from *C. poeyi*; the rounded outer corners of its disc distinguish it from *C. parcomaculata*, and the several rows of enlarged thorns on its tail separate it from *C. durbanensis*, which has a single row from nuchal region to first dorsal when young and a single row falling short of the first dorsal when older.

Description. Proportional dimensions in per cent of total length. Male, 297 mm (Harv. Mus. Comp. Zool., No. 36321). Female, 332 mm (Harv. Mus. Comp. Zool., type, No. 36320), from Cuba.

Disc: extreme breadth 54.2, 52.7; length 41.1, 40.7.
Snout length: in front of orbits 10.1, 9.5; in front of mouth 12.4, 12.3.
Orbits: horizontal diameter 4.7, 5.0; distance between 2.7, 2.6.
Spiracles: length 2.5, 2.6; distance between 6.1, 6.3.

21. Von Bonde and Swart (Fish. Mar. biol. Surv. S. Afr., Rep. 3 [1922], Spec. Rep. 5, 1924: 9, pl. 21, fig. 2). This species was referred by Barnard (Ann. S. Afr. Mus., 21 [1], 1925: 68) to the synonymy of *Raja miraletus* Linnaeus 1758, previously known from the Mediterranean and the northwest coast of Africa. But we find nothing in the published accounts or illustrations of *R. miraletus* (not seen) to suggest that its pelvics are divided, as they are in *Cruriraja parcomaculata*.

22. Fish. Mar. biol. Surv. S. Afr., Rep. 3 (1922), Spec. Rep. 5, 1924: 11, pl. 22, fig. 1.

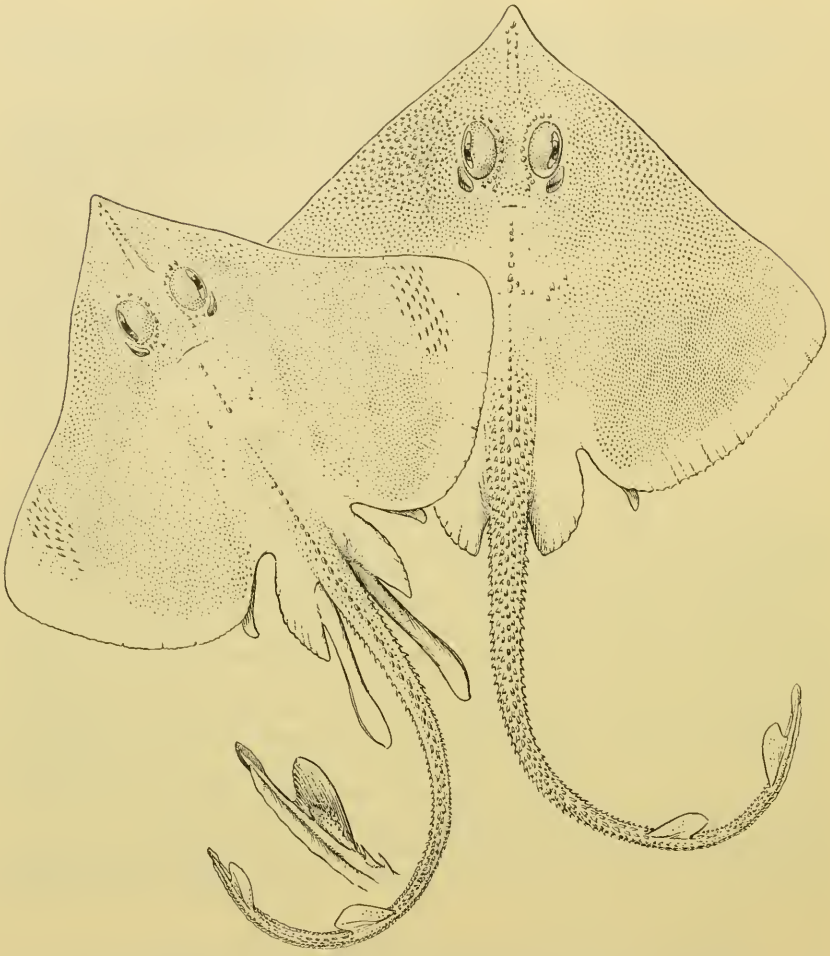


FIGURE 73. *Cruriraja atlantis*, male, 297 mm long (Harv. Mus. Comp. Zool., No. 36321) and female, 332 mm long (Harv. Mus. Comp. Zool., No. 36320, type), trawled by ATLANTIS off Santa Clara Province, north coast of Cuba, Lat. 23°22′ N, Long. 79°53′ W, 325 fathoms, and Lat. 23°12′ N, Long. 81°23′ W, 375 fathoms.

Mouth: breadth 6.2, 5.6.
Nostrils: distance between inner ends 5.2, 5.1.
Gill openings: lengths, 1st 1.2, 1.1; 3rd 1.2, 1.3; 5th 0.9, 1.0; distance between inner ends, 1st 10.8, 11.9; 5th 5.7, 6.6.

First dorsal fin: vertical height 2.4, 2.4; length of base 4.4, 3.6.
Second dorsal fin: vertical height 2.4, 1.8; length of base 3.7, 3.8.
Pelvics: anterior margin 10.4, 9.0.
Distance: from tip of snout to center of cloaca 37.3, 38.0; from center of cloaca to 1st dorsal 39.8, 41.2; to tip of tail 62.7, 62.0; from rear end of 2nd dorsal base to tip of caudal 3.7, 4.4.
Interspace between: 1st and 2nd dorsals 11.1, 9.0.

Disc about 1.3 times as broad as long, angular in front, tip of snout narrowly rounded, maximum anterior angle in front of spiracles about 80 to 95°; anterior margins weakly concave close behind tip of snout, otherwise nearly straight in females but noticeably concave again abreast of spiracles in mature males; outer corners narrowly rounded, posterior corners more broadly so; posterior and inner margins weakly convex. Axis of greatest breadth about 70 % of distance rearward from tip of snout toward axils of pectorals. Tail noticeably slender, its lateral folds originating a little before first dorsal fin, narrow anteriorly but a little wider from opposite origin of second dorsal to tip of tail; its length from center of cloaca to origin of first dorsal about 1.1 times as great as distance from center of cloaca to tip of snout, about 1.4–1.5 times as great to origin of second dorsal, and about 1.6–1.7 times as great to tip.

Half-grown specimens and larger with upper surface of disc (including skin over eyes) thickly and evenly roughened with small prickles except on tip of snout, around posterior margins of pectorals and over naked areas of varying extent on shoulder region and rearward along either side of dorsal ridge. Adults of both sexes with 2–3 rows of small thorns along anterior part of rostral ridge; 11–12 somewhat larger thorns around inner margin of orbit and 1–2 inward from inner end of spiracle; 2–4 on each shoulder; a median row of about seven thorns flanked on either side by 4–5 lower and more rounded tubercles, from nuchal region to pectoral girdle, these followed after a short gap by 4–5 small thorns and then by 5–6 much larger ones to level of axils of pectorals; the marginal regions abreast of eyes and spiracles thickly strewn with small thorns on radiate bases grading down to prickles. Anterior part of tail with 5–7 irregular rows of thorns in adult females, these decreasing in number to 2–3 rows nearing first dorsal; tails of adult males with about three irregular rows interspersed with prickles; interspace between first and second dorsals with 1–2 rows of small thorns. Pelvics smooth in both sexes, the dorsals with a few prickles. Small specimens (100 mm) with upper surface of disc largely bare of prickles except along median zone from shoulder girdle rearward; only 4–5 orbital thorns, 2–3 thorns along mid-dorsal line between nuchal region and level of axils of pectorals, and 1–2 rows along tail. Alar spines of sexually mature males in 4–5 rows. Lower surface smooth on both disc and tail.

Snout in front of orbit about 1.9–2.1 times as long as orbit, its length in front of mouth about 2.4 times as great as distance between exposed nostrils. Orbit about twice as long as width between orbits and about twice as long as spiracle. Distance

between first gill openings 2.1–2.3 times as long as distance between exposed nostrils, 1.1–1.3 times between fifth gill openings; first gill openings 1.1–1.3 times as long as fifth and about $^1/_5$ as long as breadth of mouth. Nasal curtain with narrow, irregular fringe, posterior (outer) margin of nostril smooth. Mouth nearly straight in females, considerably more arched centrally in adult males.

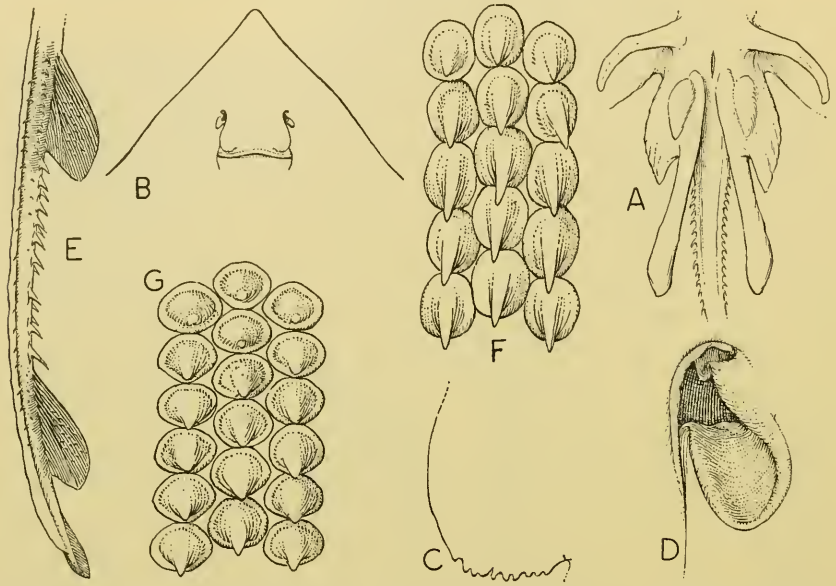


FIGURE 74. *Cruriraja atlantis*. *A* Ventral view of pelvics of male pictured in Fig. 73. *B* Lower side of anterior part of head of same. *C* Margin of right-hand nasal curtain of same, about 4×. *D* Left-hand nostril of same, about 6.5×. *E* Side view of posterior part of tail of same, about 1.3×. *F* Upper teeth of same, about 20×. *G* Upper teeth of female pictured in Fig. 73, about 20×.

Teeth in $\frac{40-42}{40-42}$ series; those of young and of females to maturity with low blunt cusp, close-set in quincunx, mostly with oval base; those of adult males with long sharp cusp at and near center of mouth, near its corners cusps triangular and bases more oval.

First and second dorsals similar in shape and about equal in size. Interspace between first and second dorsals about 2.5 times as long as base of first dorsal. Distance from rear end of base of second dorsal to origin of caudal membrane about half as long as base of second dorsal. Caudal membrane about half as long as base of second dorsal. Anterior division of pelvic about equal in length to posterior division; outer margin of posterior division moderately convex, more so in females than in males, and slightly wavy; rear tip angular, reaching back about $^1/_4$ the distance from axils of pectorals

toward first dorsal. Claspers of mature males slender, their tips simple, reaching back halfway from axils of pelvics toward first dorsal.

Anterior rays of pectorals extending only about 42–50 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface pale brown, the disc without definite markings but the tail with a dusky cross-band at the region of each dorsal fin; first and second dorsals black (a conspicuous feature) as well as caudal membrane. Lower surface whitish or yellowish; plain in young but variously blotched and washed with brown on abdomen, on posterior parts of pectorals, and on posterior lobes of pelvics of larger specimens; anterior divisions of pelvics darker brown below in males; tail pale dusky below.

Size. Judging from the claspers, a male 297 mm long is evidently close to maturity, hence it is likely that our largest specimen, a female 332 mm long, is close to the maximum size for this species.

Developmental Stages. The egg cases have not been seen.

Habits. We know only that it is a deep-water species, all specimens so far seen having been taken in depths of 280–425 fathoms.

Range. Known only off the north coast of Cuba.

Reference:

Cruriraja atlantis Bigelow and Schroeder, J. Mar. Res., 7 (3), 1948: 550 (descr., ill., off N. Central Cuba).

Cruriraja poeyi Bigelow and Schroeder 1948

Figures 75, 76

Study Material. Six males and nine females, 83 to 328 mm long, including the type, trawled by the Atlantis off Cuba, in the Harvard Museum of Comparative Zoology and U. S. National Museum; and one trawled by the U. S. Bureau of Fisheries vessel Albatross off St. Augustine, Florida (U. S. Nat. Mus., No. 123618).

Distinctive Characters. C. poeyi is separable at a glance from all other Rajidae of the western Atlantic, except *C. atlantis*, by its pelvic fins. It differs from the latter in the facts that the upper surface of its disc is largely smooth except around the eyes and snout and along the mid-dorsal zone posterior to the scapular region, and that its two dorsal fins are close together. The smoothness of its disc also separates it from *C. parcomaculata* and *C. durbanensis* from South Africa, these being more or less covered with small spines in addition to the enlarged median and orbital thorns.

Description. Proportional dimensions in per cent of total length. Male, 327 mm (Harv. Mus. Comp. Zool., No. 36322). Female, 328 mm (Harv. Mus. Comp. Zool., type, No. 36324), from Cuba.

Disc: extreme breadth 60.3, 63.5; length 48.9, 48.2.

Snout length: in front of orbits 11.3, 12.2; in front of mouth 13.7, 14.0.

Orbits: horizontal diameter 4.9, 5.2; distance between 3.1, 3.3.

Spiracles: length 2.8, 2.7; distance between 6.7, 7.9.

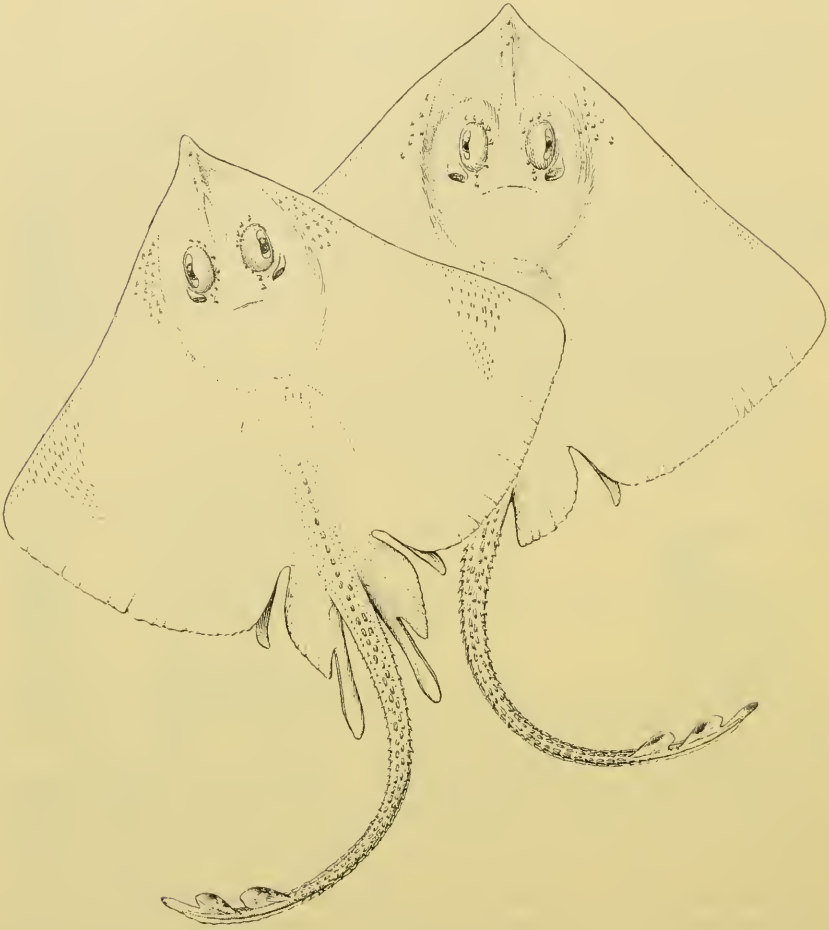


FIGURE 75. *Cruriraja poeyi*, male and female, each about 328 mm long, trawled by ATLANTIS off Santa Clara Province, north coast of Cuba, Lat. 22°50′ N, Long. 79°08′ W, 245 fathoms, and Lat. 22°48′ N, Long. 78°50′ W, 210 fathoms (Harv. Mus. Comp. Zool., Nos. 36322 and 36324, type).

Mouth: breadth 7.0, 7.0.
Nostrils: distance between inner ends 6.4, 6.4.
Gill openings: lengths, 1st 1.4, 1.4; 3rd 1.5, 1.5; 5th 1.1, 1.0; distance between inner ends, 1st 11.3, 13.7; 5th 6.0, 7.6.
First dorsal fin: vertical height 2.4, 1.8; length of base 4.1, 4.0.

Second dorsal fin: vertical height 2.6, 1.8; length of base 4.3, 4.6.
Pelvics: anterior margin 13.5, 12.5.
Distance: from tip of snout to center of cloaca 41.7, 42.7; from center of cloaca to 1st dorsal 44.8, 43.2; to tip of tail 58.3, 57.3; from rear end of 2nd dorsal base to tip of caudal 4.0, 4.0.
Interspace between: 1st and 2nd dorsals 1.1, 1.2.

Disc about 1.2–1.3 times as broad as long, angular in front, tip of snout only a little blunted; maximum anterior angle in front of spiracles about 100° in females and about 85° in males; anterior margins weakly concave close behind tip of snout and again at level of spiracles; outer corners narrowly rounded but posterior corners broadly so; posterior margins weakly convex; inner margins nearly straight. Axis of greatest breadth about 65–70 % of distance back from snout toward axils of pectorals. Tail with lateral folds extending from about midway between tips of pelvics and origin of first dorsal nearly to tip of tail, widest opposite dorsals; distance from center of cloaca to first dorsal about as great as distance from center of cloaca to tip of snout, about 1.1–1.2 times as great to second dorsal, and 1.3–1.4 times as great to tip of tail.

Upper surface of disc of adults prickly only along mid-dorsal ridge posterior to pectoral girdle and narrowly along anterior margins from level of eyes rearward; 1–3 large thorns and a few smaller ones on anterior part of rostral ridge; 7–8 in malar regions between orbits and outer margins in females but up to 20 or more there on males; 7–8 thorns around inner margin of orbit, the series usually interrupted midway, with 1–2 inward from spiracles; likewise a median row of about 7–9 from about halfway between pectoral and pelvic girdles to level of axils of pectorals; tail with 4–5 irregular rows along anterior part, about four rows along posterior part to first dorsal, the thorns spaced progressively wider rearward, no one row exactly in the midline; interspace between first and second dorsals with two pairs of thorns, the members of each pair side by side; the dorsals prickly; caudal membrane and pelvics smooth. Alar thorns of mature males covering a triangular area, broadest anteriorly, based a little in advance of outer corners of pectorals. Young specimens with fewer orbital thorns, only about three rows on tail and none outward from orbits. Lower surface smooth both on disc and on tail.

Snout in front of orbits about 2.3 times as long as orbit, its length in front of mouth 2.1–2.2 times as great as breadth between exposed nostrils. Orbit about 1.6 times as long as distance between orbits and 1.8 times as long as spiracle. Distance between first gill openings 1.8–2.1 times as long as distance between exposed nostrils, 0.9–1.2 times between fifth gill openings; first gill openings 1.3–1.4 times as long as fifth and about $^1/_5$ as long as breadth of mouth. Nasal curtain more or less conspicuously fringed with short rounded lobelets;[23] posterior (outer) margin of nostrils smooth. Mouth nearly straight.

23. On one specimen the nasal curtain is fringed on one side and smooth on the other.

Teeth $\frac{46-50}{44-48}$; those of females close-set in quincunx, circular to oval at base and with low triangular cusp except near corners of mouth where base is more oval and cusps are usually lacking, the anterior rows much worn and nearly smooth; those of adult males with long sharp cusps, pointing obliquely outward near center of mouth beside the symphysis, those toward outer corners of mouth with low triangular cusps.

First and second dorsals similar in size and shape, the posterior margin somewhat re-entrant. Interspace between dorsals about $^1/_3$ as long as base of first dorsal.

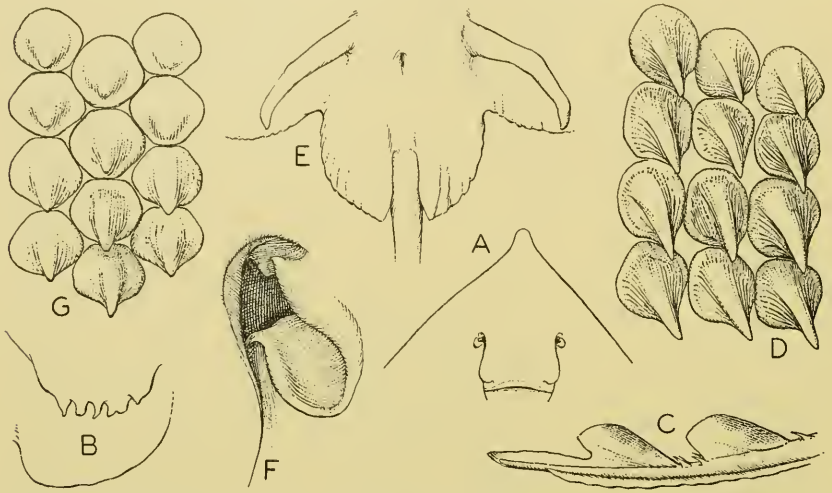


FIGURE 76. *Cruriraja poeyi*. *A* Lower side of anterior part of head of male pictured in Fig. 75. *B* Margins of right-hand (above) and left-hand (below) nasal curtains of same, about 5.8×. *C* Side view of posterior part of tail of same, about 1.2×. *D* Upper teeth of same, from near center of jaw, about 12×. *E* Ventral view of pelvics of female pictured in Fig. 75. *F* Left-hand nostril of same, about 6.9×. *G* Upper teeth of same from near center of jaw, about 14×.

Caudal membrane posterior to second dorsal about as long as base of first dorsal. Anterior division of pelvics about as long as posterior division, the latter strongly convex outwardly and slightly wavy in females and in young males, only weakly convex in adult males; rear tips subangular, reaching back about $^1/_4$ the distance from axils of pectorals toward first dorsal. Claspers of mature males slender with simple tips, reaching back a little less than halfway from axils of pelvics toward first dorsal.

Anterior rays of pectorals extending about 49–55 % of distance from level of fronts of orbits toward tip of snout.

Color. Upper surface pale coffee brown except for a translucent area either side of rostral cartilage, usually with roundish dark spots, about half as long as orbit, scattered over disc posterior to spiracles except along outer posterior margins; anterior

parts of dorsals and tip of caudal membrane black. Lower surface of disc of about same shade as upper surface, somewhat mottled paler and darker; pale areas around mouth and gill openings; tail paler below than disc.

Size. The largest seen is 328 mm long, and a male of nearly this size has well developed claspers, suggesting that the maximum length for this species is probably not much greater than 400 mm.

Developmental Stages. The egg cases have not been seen.

Habits. All the specimens taken thus far have been trawled on hard sandy bottom in depths of 210–475 fathoms.

Range. Known only off the north central and southwest-central coasts of Cuba and off St. Augustine, Florida.

Reference:

Cruriraja poeyi Bigelow and Schroeder, J. Mar. Res., 7 (3), 1948: 555 (descr., ill., off N. coast of Cuba).

Genus *Dactylobatus* Bean and Weed 1909

Dactylobatus Bean and Weed, Proc. U. S. nat. Mus., *36*, 1909: 459; type species, *D. armatus* Bean and Weed. From offing of South Carolina, 258 and about 270 fathoms.[24]

Generic Characters. Rajidae with the six to eight median rays of each pectoral elongated to form a narrow spatula-shaped lobe. Outer margins of pelvics so weakly concave that fins are not definitely bilobed. Cranium with rostral cartilage extending nearly to tip of snout (as in *Raja*). Tips of anterior rays of pectorals reaching almost to level of tip of rostral cartilage. Characters otherwise those of the family.

Species. D. armatus Bean and Weed 1909 is the only species of the genus known.

Dactylobatus armatus Bean and Weed 1909

Figures 77, 78

Study Material. Immature male, 278 mm long, with small claspers, from offing of South Carolina, Lat. 32°36′ N, Long. 77°29′ W, in 258 fathoms, and a female, 264 mm, from Lat. 31° N, Long. 80° W, in about 270 fathoms, in U. S. National Museum.

Distinctive Characters. The presence of a narrow spatula-shaped lobe projecting from the margin of each pectoral at about its midlength gives to *Dactylobatus armatus* an outline that has no counterpart among other batoids.

Description. Proportional dimensions in per cent of total length. Male, 278 mm, from Lat. 32°36′ N, Long. 77°29′ W (U. S. Nat. Mus., cotype, No. 62914).

Disc: extreme breadth 72.5; length 51.1.

Snout length: in front of orbits 11.5; in front of mouth 13.3.

Orbits: horizontal diameter 3.8; distance between 4.0.

24. Collected by the ALBATROSS on October 21, 1885 and on May 5, 1886.

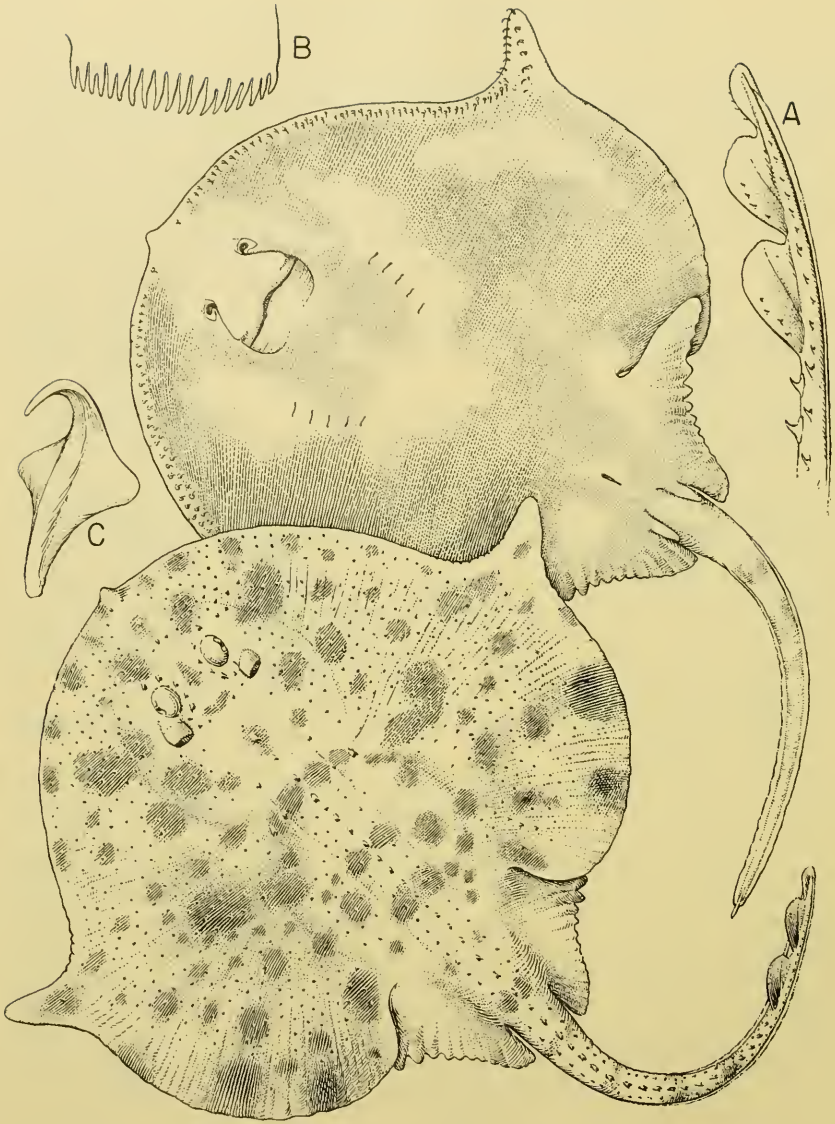


FIGURE 77. *Dactylobatus armatus*, male, 278 mm long, from off South Carolina, Lat. 32°36′ N, Long. 77°29′ W, 258 fathoms, ALBATROSS St. 2624 (U. S. Nat. Mus., No. 62914). *A* Side view of posterior part of tail, about 1.4×. *B* Margin of left-hand nasal curtain, about 8×. *C* Hooked thorn from lower surface of outer corner of pectoral fin, about 14×.

Spiracles: length 2.9; distance between 7.4.
Mouth: breadth 9.5.
Nostrils: distance between inner ends 5.6.
Gill openings: lengths, 1st 1.4; 3rd 1.6; 5th 1.3; distance between inner ends, 1st 14.7; 5th 10.4.
First dorsal fin: vertical height 2.7; length of base 6.1.
Second dorsal fin: vertical height 2.3; length of base 5.7.
Pelvics: anterior margin 11.9.
Distance: from tip of snout to center of cloaca 48.2; from center of cloaca to 1st dorsal 36.7; to tip of tail 51.8; from base of 2nd dorsal to tip of caudal 3.2.
Interspace between: 1st and 2nd dorsals 0.0.

Disc including lateral lobes about 1.4 times as broad as long, or about 1.1 times as broad as long disregarding the lobes; its anterior contour, back about to level of shoulders, nearly an even semicircle; position of tip of snout marked by a low rounded prominence; posterior corners so broadly rounded that outer-posterior and inner-posterior margins merge without evident transition; posterior corners slightly overlapping pelvics; median 6–8 rays of each pectoral prolonged, forming a narrow spatula-shaped lobe that tapers somewhat to a rounded tip and extends out from the general contour line of the fin by a distance about equal to that between spiracles. Axis of greatest breadth (disregarding lobes) about 65 % of distance from snout toward rear margins of disc. Tail with narrow lateral folds beginning about an eye's diameter posterior to tips of pelvics and extending almost to tip, widest posteriorly; length of tail from center of cloaca to first dorsal about 0.76 as great as distance from center of cloaca to tip of snout, 0.89 as great to second dorsal, and 1.07 times as great to tip.

Upper surface of disc sparsely strewn with minute and low conical thorns, their tips only breaking the skin; four or five larger curved thorns outlining each orbital ridge, with a smaller pair inward from each spiracle; one large, and one or two smaller ones on each shoulder; one small thorn midway between scapular thorns and spiracle; a row of larger and smaller thorns along midline of back from nuchal region to first dorsal fin, the largest ones on anterior part of tail, about 17–18 in number anterior to axils of pectorals, about 22 thence to first dorsal; this median row of thorns flanked on either side of disc by occasional smaller thorns and along tail by a more continuous though irregular series, with a few still smaller thorns low down on its sides; skin above eyes prickly; pelvics smooth; dorsals and caudal membrane with a few small sharp prickles. Lower surface edged with an irregular double row of sharp thorns from tip of snout rearward around head and anterior margins of disc to pectoral lobes, their points curved inward toward median line of disc; three irregular rows along anterior edge of each pectoral lobe; otherwise smooth below.

Snout in front of orbits about three times as long as orbit, its length in front of mouth about 2.4 times as great as distance between exposed nostrils. Orbit about as long as distance between orbits and 1.3 times as long as spiracle. Exposed nostril small,

about halfway between mouth and tip of snout, its expanded posterior (outer) margin a little jagged. First to third gill openings (longest) about half as long as eye; distance between inner ends of fifth gills about twice as long as distance between nostrils. Free margin of nasal curtain shorter than in most rajids, deeply fringed with narrow rounded lobelets. Mouth a little arched centrally in young specimens, perhaps more so in males at maturity.[25]

Teeth $\frac{66}{66}$ in specimen counted, moderately close-set in quincunx, thorn-like with needle-sharp cusp curved rearward (into the mouth) on longitudinally oval base; only about three rows in function simultaneously in small specimens but perhaps more in larger ones.

FIGURE 78. *Dactylobatus armatus*, same as in Fig. 77. *A* Mouth and nostrils, about 1.8×. *B* Lower surface of outer corner of left-hand pectoral fin, about 1.8×. *C* Upper teeth from near center of jaw, about 17×.

Dorsal fins rounded, close to tip of tail, confluent at base or nearly so, without intervening thorn; base of first dorsal about as long as distance between orbits, the second dorsal a little smaller. Caudal membrane about 37 % as long as base of first dorsal. Pelvics only weakly concave outwardly but continuously so nearly to rear tips and rather strongly scalloped along midsector; anterior margin about 65 % as long as distance from its own origin to rear tip of pelvic; tip of anterior lobe rather narrowly rounded, rear corners narrowly so, reaching back a little more than $\frac{1}{3}$ the distance from axils of pectorals toward first dorsal. Claspers of mature male not seen.

Anterior rays of pectorals reaching nearly to level of tip of snout.

Color. Upper surface ashy gray after many years in alcohol; irregularly marked with sooty or blackish spots and blotches of different sizes, round to long-oval in shape; upper margins of first and second dorsals sooty. Lower surface yellowish white, vaguely clouded with mouse gray but described as appearing more or less pinkish with brown spots after removal of the mucous that is coagulated by the preservative; posterior margins of pectorals and pelvics smoky.

Size. The claspers of a male 278 mm long are so small (Fig. 77) as to suggest

25. Sexually mature specimens have not been seen.

that *Dactylobatus* is one of the medium-sized if not larger members of its family, but its size at maturity is not known.

Developmental Stages. Nothing known.

Habits. The depths of capture, 258 and about 270 fathoms, suggest at least a moderately deep-water habitat. One of the two specimens taken was from a temperature of about 12° C (54° F). Nothing more is known of its habits.

Range. Known only from the upper part of the continental slope in the offing of South Carolina, at the localities and depths listed (Study Material, p. 323).

References:

Dactylobatus armatus Bean and Weed, Proc. U. S. nat. Mus., *36*, 1909: 459, pl. 38 (descr., ill., upper continental slope in offing of S. Carolina); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 368 (descr., after Bean and Weed, 1909); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 27 (listed, S. Carolina).

Family ANACANTHOBATIDAE

Characters. Rajoidea with tip of snout extended as a filament. Tail without lateral folds. No dorsal fins, but with caudal membrane. Pelvics so deeply notched outwardly that anterior subdivisions of fins are leg-like, of two segments, resembling pelvics of the rajid genus *Cruriraja* (p. 314) and *Typhlonarke* among Electric Rays (p. 80); inner margins of posterior lobes attached to sides of tail nearly or quite to tips. Skin smooth everywhere, without denticles of any sort either on disc or on tail.

Remarks. The type genus of this family, *Anacanthobatis* von Bonde and Swart 1924, is placed in the family Dasyatidae by Fowler[26] and by Smith.[27] But the nature of its pelvics refers it, rather, to the Rajoidea.

Genera. Two genera are known, *Anacanthobatis* von Bonde and Swart 1924, from the Natal Coast, South Africa, and *Springeria* Bigelow and Schroeder 1951 from the Gulf of Mexico.

Key to Genera

1a. Outer margins of posterior lobes of pelvic fins not united to inner margins of pectorals; snout prolonged as a simple filament.

Anacanthobatis[28] von Bonde and Swart 1924.
Natal Coast, South Africa.

1b. Outer margins of posterior lobes of pelvics united along first half to two-thirds of

26. Bull. U. S. nat. Mus., 100 [*13*], 1941: 397.
27. Sea Fish. S. Afr., 1949: 71.
28. The type and only known species was described and figured (von Bonde and Swart, Mar. biol. Surv. S. Afr., Rep. 3 [1922], Spec. Rep. 5, 1924: 18, pl. 23) as *Leiobatis marmoratus*, and *Anacanthobatis* was proposed as a substitute in the attached "errata slip" because *Leiobatis* was preoccupied. The original illustration was of a female; Smith (Sea Fish. S. Afr., 1949: 71, fig. 84) has recently pictured a male. A second species, *dubius*, included by von Bonde and Swart in *Anacanthobatis* (Mar. biol. Surv. S. Afr., Rep. 3 [1922], Spec. Rep. 5, 1924: 19) is referred provisionally to *Springeria* because the outer margins of its pelvics are described as fused along their anterior half with the inner margins of the pectorals. But its status will remain somewhat doubtful until it is known whether it has dorsal fins or not.

their length to inner margins of pectorals; snout either expanded terminally in form shown in Fig. 78 α or prolonged as a simple filament.

Springeria Bigelow and Schroeder 1951, p. 328.

Genus *Springeria* Bigelow and Schroeder 1951

Figure 78 α

Springeria Bigelow and Schroeder 1951: J. Wash. Acad. Sci., *41* (3), 1951: 111; type species, *S. folirostris* Bigelow and Schroeder; Gulf of Mexico off mouth of Mississippi River, Lat. 29°02′ N, Long. 88°34′ W., 232–258 fathoms.

Generic Characters. Snout either prolonged as a simple filament or expanded terminally as shown in Fig. 78 α. Lower side of tail as well as upper with caudal membrane. Outer margins of posterior lobes of pelvics united along first $^2/_3$ of their length with inner margins of pectorals; inner margins of posterior pelvic lobes attached nearly to tips to sides of tail. No radial cartilages along anterior half of basipterygial cartilages of pelvic fins. Pelvis transverse, its anterior profile slightly concave rearward, a long slender process at either end directed forward. Firm rostral cartilage extending to base of filament. Other characters those of the family (p. 327).

Species. Two species known, *S. folirostris* Bigelow and Schroeder 1951, from Gulf of Mexico, probably also *dubia* (von Bonde and Swart) 1924, South Africa (see p. 327, footnote 28).

Key to Species

1 a. Snout prolonged as a simple filament. *dubia* von Bonde and Swart 1924. South Africa.[29]

1 b. Snout expanded terminally in leaf-like form (Fig. 78 α).

folirostris Bigelow and Schroeder 1951, p. 328.

Springeria folirostris Bigelow and Schroeder 1951

Figure 78 α

Study Material. Immature male, type, 400 mm long to base of terminal filament, from northern Gulf of Mexico off the Mississippi River, Lat. 29°02′ N, Long 88°34′ W, in 232–258 fathoms (U. S. Nat. Mus., No. 152546); very young male, 125 mm long, from same general locality, Lat. 29°01′ N, Long. 88°30′ W, in Harvard Museum of Comparative Zoology. Also 11 others, of both sexes, 220–620 mm long, from the north central and northeastern parts of the Gulf of Mexico, collected by U. S. Fish and Wildlife Service vessel Oregon in 185–254 fathoms, September 1951, at stations 476, 481, and 489.

Distinctive Characters. S. folirostris differs from all other known batoids in the

29. Status doubtful; see p. 327, footnote 28.

peculiar leaf-like expansion of the end of its snout. Specimens with this, even though the tail were damaged, would still be easily separable from all other rajoids of the Atlantic by their perfectly naked skins, and from all dasyatid and myliobatid Rays by the nature of their pelvic fins.

FIGURE 78α. *Springeria folirostris*, holotype, male, 422 mm long, from northern Gulf of Mexico, Lat. 29°02′ N, Long. 88°34′ W, 232–258 fathoms (U. S. Nat. Mus., No. 152546). *A* Tip of tail, about 2.3×. *B* Nasal curtain and mouth, about 2.3×. *C* Teeth from upper jaw, about 9×.

Description. Proportional dimensions in per cent of total length. Male, 400 mm to base of terminal filament (U. S. Nat. Mus., type, No. 152546), and female, 620 mm, both from the Gulf of Mexico.

Disc: extreme breadth 51.6, 53.3; length 55.3, 57.2.
Snout length: in front of orbits 21.8, 22.4; in front of mouth 24.3, 24.3.
Orbits: horizontal diameter 2.9, 3.3; distance between 2.6, 2.6.
Spiracles: length 1.0, 1.5; distance between 5.1, 5.0.
Mouth: breadth 4.5, 4.8.
Nostrils: distance between inner ends 3.8, 4.0.
Gill openings: lengths, 1st 0.75, 1.0; 3rd 0.75, 1.0; 5th 0.5, 0.6; distance between inner ends, 1st 9.2, 10.5; 5th 4.8, 5.6.
Caudal fin: length of base, upper 6.0, 3.7; lower 5.0, 4.4.
Pelvics: anterior margin 12.7, 12.2.
Distance: from tip of snout[30] to center of cloaca 47.6, 50.0; from center of cloaca to tip of tail 52.4, 50.0.

Disc from base of terminal filament about 1.1 times as long as broad; maximum anterior angle from level of base of terminal expansion of snout to level of spiracles about 85°; end of snout expanded in leaf-like form as shown in Fig. 78 α, terminating in a slender filament a little longer than distance between spiracles; margins of disc rearward from terminal expansion weakly concave or straight about to level of spiracles, then altering to continuously and strongly convex around to short inner margins, without definite outer or posterior corners. Tail slender, compressed dorsoventrally, increasingly so rearward; its width at axils of pelvic fins (where thickest) about $^1/_2$–$^3/_4$ as great as length of eye; its length from center of cloaca to tip about 1.0–1.1 times as great as distance from cloaca to base of terminal filament of snout.

Skin completely naked everywhere, without dermal denticles of any sort.

Snout in front of eyes about 8.4–8.7 times as long to base of terminal filament as distance between orbits, its length in front of mouth about 6.0–6.5 times as great as distance between exposed nostrils. Orbit about 1.1 times as long as distance between orbits, and 2.2–2.9 times as long as spiracle, which is noticeably small. Gill openings minute; first about $^1/_6$ as long as breadth of mouth; fifth about $^2/_3$ as long as first; distance between inner ends of first gills about 2.5 times as long as distance between exposed nostrils, between fifth gills about 1.3 times. Nasal curtain conspicuously fringed, each side with 10–11 lobelets; outer margin of nostril only slightly expanded with irregular edge; exposed nostril noticeably minute. Mouth on immature males and on females a little arched forward, its shape not known for mature males.

Teeth $\frac{22-26}{22-27}$ on young males, low, with obscure cutting edge but no cusp, but $\frac{30}{28}$ on largest female, with low, broad triangular cusp, arranged in quincunx. Teeth of mature males not seen.

No dorsal fins. Base of upper caudal fin-membrane about 1.0–1.6 times as long as distance between exposed nostrils, of shape illustrated in Fig. 78 α, its maximum width about $^1/_{10}$ (about 9 %) as great as length of its base; lower caudal membrane about half (55 %) as wide as upper, its origin a little posterior to origin of upper; the two

30. Exclusive of rostral filament, which is 22 mm long.

lobes discontinuous at tip of tail. Anterior leg-like subdivision of pelvics nearly as long (95 %) as distance from pelvic origin to rear corners, broader than thick, fleshy, with one articulation about midway of its length, inner edge of the terminal segment scalloped, corresponding to tips of the three radial cartilages; posterior lobe of pelvics with narrowly rounded rear corner reaching rearward only about as far as rear limits of disc; outer margin joined for about $^2/_3$ its length to margin of pectoral, inner edge joined to side of tail nearly to tip.

Anterior rays of pectorals extending forward to a little posterior to base of terminal expansion of snout; firm rostral cartilage reaching about to base of terminal filament.

Color. Ash gray above, except for unpigmented and translucent spaces between rostral ridge and anterior rays of pectorals; orbits dusky; terminal expansion of snout narrowly and irregularly margined with black; posterior part of back with a sooty blotch on one side near midline on largest male, several such blotches, haphazardly located, on largest female. Lower surface pale grayish white, the outer posterior belt of pectorals sooty gray, terminal expansion of snout narrowly and irregularly edged with black; tail sooty at base.

Size. How large this Skate may grow is not known, for the largest male seen so far, 400 mm long to base of terminal filament, is immature, its claspers not yet reaching as far as the tips of its pelvics.

Developmental Stages. Presumably *Springeria* is oviparous like other rajids, but its eggs have not been seen.

Habits. All the specimens seen were trawled at 185–258 fathoms; this, with the improbability that this Skate would have been overlooked if it occurred in shallow water, suggests that it is confined to depths greater than about 150 fathoms. Nothing else is known of its habits.

Range. So far known only in the northern side of the Gulf of Mexico at the localities listed on page 328 under Study Material.

Reference:

Springeria folirostris Bigelow and Schroeder, J. Wash. Acad. Sci., *41* (3), 1951: 112 (descr., ill., Gulf of Mexico).

Suborder MYLIOBATOIDEA

Sting Rays, River Rays, Butterfly Rays, Eagle Rays, Cow-nosed Rays, Devil Rays, Mantas

Characters. Head and trunk anterior to axils of pectorals strongly flattened dorsoventrally, forming a disc with the pectorals, essentially as in Rajoidea; disc ranging from oval longitudinally to much broader than long. Tail sharply marked off from body sector, ranging from shorter than disc to much longer, in many cases like a whiplash toward tip. Pectorals either continuous along sides of head or with anterior portions separated along head as independent rostral lobe (or lobes) or as fin-like structures.

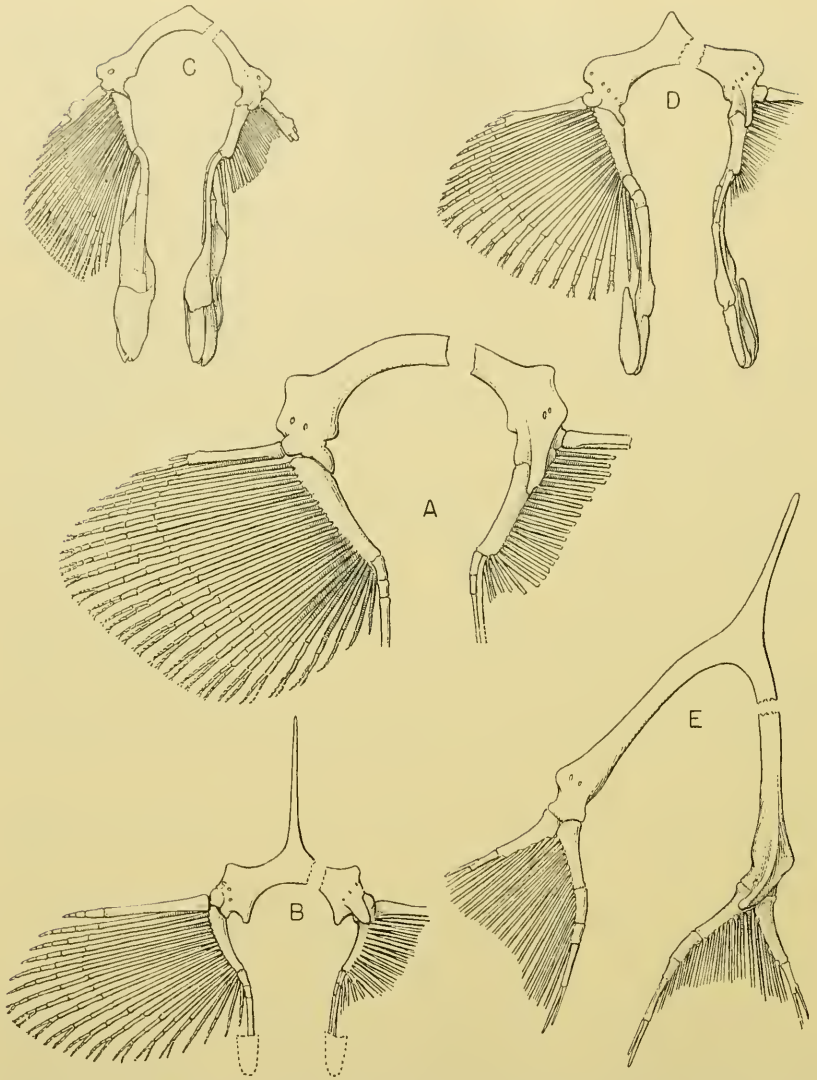


FIGURE 79. Pelvis of Myliobatoidea, ventral view (left) and dorsal view (right). A *Dasyatis centroura*, after Garman. B *Potamotrygon circularis*, after Garman. C *Gymnura altavela*, after Garman. D *Myliobatis freminvillii*, after Garman. E *Mobula hypostoma*, about 1,070 mm wide, from Cape Lookout, North Carolina (Harv. Mus. Comp. Zool., No. 1378), about 0.6×.

A single dorsal fin situated far forward on tail, or none. A well developed caudal fin with radial supports in some but not in others. Outer margins of pelvics either straight or convex.[1] Spiracles with no trace of gill folds.

Eyes and spiracles either on dorsal surface of head or on its sides. Apparent inner (morphologically anterior) margins of nostrils united and expanded rearward as a curtain, either simple or bilobed, the free posterior edge either smooth or fringed, concealing all but outer end of nasal aperture. Teeth ranging from small and numerous to large and few in number and compacted as a single grinding plate in each jaw.

Skin of upper surface either naked or variously armed with tubercles or thorns, the lower surface either naked or nearly so. Upper surface of tail with a large and saw-edged poisonous spine (or spines) in many species but not in all.

Anterior part of head supported either solely by anterior radial cartilages of pectoral fins or, in the case of the Devil Rays (Mobulidae), by the anterior contour of the cranium, which is nearly straight transversely.[2] Cranium without rostral projection; antorbital cartilages not supporting part of disc. Fins without horny rays (ceratotrichia), the cartilaginous radials extending out to margins of pectorals and pelvics, as well as to margins of dorsal if present. Pelvis (Fig. 79) more or less strongly arched forward, without prepelvic processes at outer ends and with or without a median process directed forward. Surfaces of gill arches inward from gill filaments either smooth, or with papillae, or with knobs or transverse folds or ridges (Fig. 80).

Size. The members of this suborder range from only a few inches up to 22 or 23 feet in breadth and reach a weight of more than 3,000 pounds in the case of the Giant Devil Rays (*Mobula* and *Manta*), which are by far the largest of all batoids and indeed among the largest of fishes.

Developmental Stages. Ovoviviparous in all species in which development is known.

Range. As a whole, the suborder is tropical-subtropical, only a few species ranging regularly to warm-temperate latitudes. For the most part they are confined to small and moderate depths and are most common in shallow water, where they are plentiful in suitable situations around tropical shores. Many of them enter brackish and fresh water freely, and one family of the order is confined to fresh water.

Families. As seen in the list of names at the beginning of this section, the suborder includes a varied assemblage, all members of which agree in the characters stated above.

Key to Families

1a. A well developed caudal fin with cartilaginous radial supports. *Urolophidae*, p. 416.

1b. No caudal fin.

2a. Outer anterior margins of pectorals continuous along sides of head, without separate cephalic fins or rostral lobes; eyes and spiracles on top of head.

1. This contrasts with their usual concavity in the Rajoidea, as does the position of the dorsal fin.

2. For a general account of the head skeleton in the families Dasyatidae and Myliobatidae, see Holmgren (Acta Zool. Stockh., *22*, 1941: 62, 66).

3a. Disc not more than 1.3 times as broad as long; tail from center of cloaca to tip longer than breadth of disc; no distinct dorsal fin; transverse curtain on roof of mouth with fringed margin; floor of mouth with several fleshy papillae.

4a. Pelvis not bearing a slender median process directed forward; salt- and brackish-water species. Dasyatidae, p. 335.

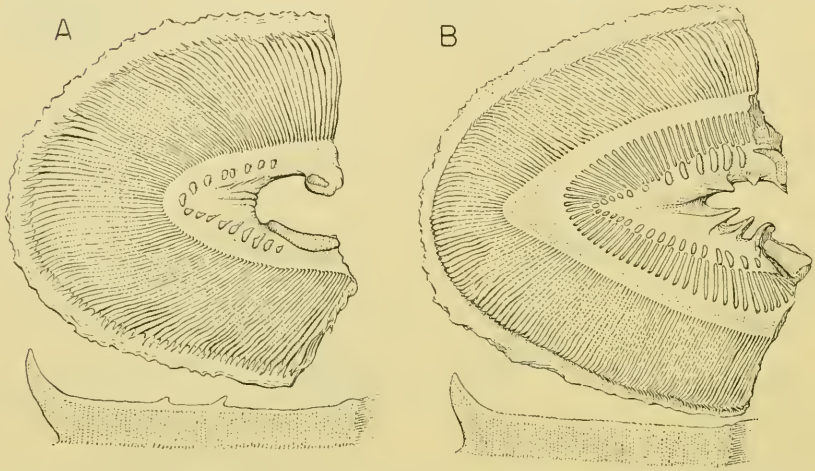


FIGURE 80. Gill arch (above) and lateral view of gill fold (below) of Myliobatoidea; left, *Myliobatis goodei*, 990 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 994), 0.65×; right. *Rhinoptera bonasus*, 774 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 374), about 1.3×.

4b. Pelvis bearing a long slender median process, directed forward; fresh-water species exclusively. Potamotrygonidae.
Rivers of Atlantic and Caribbean watersheds in tropical and warm-temperate South America.

3b. Disc more than 1.5 times as broad as long; tail from center of cloaca to tip considerably shorter than breadth of disc; with or without a small dorsal fin near midlength of tail; transverse curtain on roof of mouth smooth-edged; no papillae on floor of mouth. Gymnuridae, p. 395.

2b. Margins of pectorals deeply indented or entirely interrupted just posterior to eyes, the anterior part of head thus sharply marked off from remainder of disc; anterior subdivisions of pectorals forming a separate lobe (or lobes), or fins; eyes and spiracles on sides of head.

5a. Anterior subdivisions of pectorals in the form of two thin and narrow

fin-like projections widely separated (Figs. 113, 116); teeth minute, in many series. Mobulidae, p. 480.

5b. Anterior subdivisions of pectorals forming either one soft fleshy lobe extending forward below front of head, or two such lobes joined together basally; teeth large, in few series.

6a. A single subrostral lobe or fin (Fig. 102). Myliobatidae, p. 433.

6b. A pair of subrostral lobes or fins (Fig. 107). Rhinopteridae, p. 465.

Family DASYATIDAE

Sting or Whip Rays

Characters. Myliobatoidea with anterior portions of pectorals continuous along sides of head, not separated off as subrostral lobes or fins; anterior part of head not marked off from more posterior part of disc; crown only slightly elevated; disc not more than 1.3 times as broad as long. Tail slender, tapering, much longer than disc in many species; some species with a longitudinal membranous fold (or folds) above or below, or both. Upper surface of tail armed in most species with one or more long and sharp-pointed poisonous spines with serrate edges, flattened dorsoventrally and attached rigidly to skin; tail spines directed rearward with tip lifted only slightly above general contour of tail, the one close behind the other if there are two or more; marginal teeth of spine directed toward its base, their outer edges forming cutting edges interrupted only by short interspaces between one tooth and the next. No rayed dorsal or caudal fins. Eyes without expanded velum above pupil; eyes and spiracles on dorsal surface. Nostrils separate from mouth, their anterior margins widely expanded and confluent across a narrow isthmus, forming a single quadrate curtain with more or less deeply fringed margin reaching rearward as far as front of mouth; outer posterior margin of nostril expanded as a rounded lobe directed forward. Mouth straight or slightly arched, on ventral surface considerably posterior to snout, the lower jaw more or less indented centrally with the upper jaw curved rearward to correspond;[3] floor of mouth with a transverse row of several fleshy papillae of various lengths, their tips often more or less swollen. Teeth small, in numerous series, closely crowded in bands along jaws, rounded or with one or more cusps, often with ridges or tubercles. Upper surface of disc and tail (apart from tail spine) smooth or variously roughened with tubercles, thorns or prickles. Front of cranium weakly concave in most, perhaps straight in some. Pelvis moderately arched forward in rounded contour but without median process.[4] Surfaces of gill arches smooth inward from gill filaments.

Remarks. The tail spine is a striking anatomical feature of all but one of the known

3. This direction of curvature is opposite to that usual among Rajidae.

4. In the freshwater genera *Potamotrygon* and *Disceus* the pelvis bears a long median process extending forward (Fig. 79B), and it is because of this that they were grouped by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 415) in the separate family Potamotrygonidae, which is accepted here for this same reason. In all other respects (other than their freshwater habitat) they agree with the typical Dasyatidae.

genera of the family. It has been described as renewed yearly, but we find no definite evidence that its replacement follows any regular periodic schedule, nor does this seem likely to us. While the majority of specimens are armed with a single spine, others have two, rarely three or even four, showing that new spines may develop before the old one is dropped. On the other hand, it is not unusual to find specimens with tails from which the spine has been dropped (leaving only a scar) before any trace is to be seen of the spine that should succeed it. At least in some species the replacement spine may develop either close anterior to the pre-existing one or close posterior to it.[5] However, in other species it may be that the replacement spine invariably develops either anterior to the older one (Figs. 83 and 90, *Dasyatis centroura* and *D. say*) or posterior to it (*Dasyatis sabina*, Fig. 88).

The upper (anterior) surface of the spine varies from low-half-oval to nearly semicircular in cross section; its lower (posterior) surface has a rounded median ridge flanked on either hand by a deep furrow extending nearly to the tip; the rows of marginal teeth mark the transition from upper surface to lower. Although the spine itself is not mobile, the tail is so flexible that it swings far away from the terminal part of the spine when lashed about, thus bringing the spine into a position favorable for penetrating whatever it may strike. The tails of large specimens are so powerful that it is not exceptional for their spines to drive through a heavy boot and several layers of clothing, to penetrate full length into an arm or leg, or to pierce the side of a wooden boat deeply. Comparative anatomists and ichthyologists of the twentieth century commonly regarded the effects of Sting Ray wounds (p. 333) as due to mechanical injury and to infection by the mucus of the Ray's skin rather than to any specific poison. But as long ago as 1848[6] it was pointed out that the symptoms following these wounds are similar to those resulting from bites by poisonous snakes. It seems well established now that the spines do secrete a poison from cells lying in the lateral grooves along the side that faces the tail.[7] While the evidence to this effect is circumstantial, the pain and swelling follow far sooner after the wound is inflicted than might be expected in the case of an ordinary infection. The effects resemble so closely the effects of wounds by the European Weaver Fishes, *Trachinus* (proved venomous by clinical experiments of various kinds), and the secretory organ of the Sting Ray resembles that of *Trachinus* so closely in histological structure, as to leave no reasonable doubt of the venomous nature of the spine.[8] And the final proof has recently come from laboratory experiments on the properties of their venom[9] and on the effects of

5. In *Dasyatis imbricata* (Bloch and Schneider) 1801 from the East Indies, the replacement spine is posterior in two out of 17 double-spined specimens that we have examined, anterior in the others.
6. By R. Schomburgk; see p. 339, footnote 24.
7. See Evans (Philos. Trans., [B] *212*, 1923: 1–33) for the histology of the spine organ, Jorg (Nuov. Reun. Soc. Argent. Patol. Reg., 1939: 1599–1616) for the closely allied Potamotrygonidae, and Evans (Sting Fish and Sea Farer, 1943) for a popular account of venomous fishes.
8. For an extended historical account of the effects of Sting Ray wounds, see Gudger (Bull. Hist. Med., *14*, 1944: 467–504).
9. Vellard (C. R. Acad. Sci. Paris, *192*, 1931: 1279; Mém. Soc. zool. Fr., *29*, 1932: 514–532); see also full summary and discussion by Gudger (Amer. Nat., *81*, 1947: 297). We might point out also that Jorg (Nuov. Reun. Argent. Patol. Reg., *3*, 1939: 1603), who arrived at a contrary conclusion for *Potamotrygon*, did not study the histology

injecting the poisonous tissue from the spines of two species of Brazilian River Rays (*Potamotrygon*) into various batrachians, birds and mammals.

Size. The members of the family vary widely in size, the smallest being only one to two feet across the disc at maturity, the largest[10] six to seven feet and perhaps more.

So far as we can learn, none of the largest ones have ever been weighed, but from the relationship between size and weight for *Dasyatis centroura* up to five feet broad (p. 357), we suspect that estimated weights reported for large Rays are likely to be considerably too high.

No information is at hand as to the rate of growth of any of the Sting Rays or the number of years required by the larger species to reach full size. But at least some of them are long-lived, for one is known to have "lived for 16 years in captivity in Berlin."[11]

Developmental Stages. The dasyatid Rays are ovoviviparous, the embryos lying loose in the uterus without any physical connection with the mother. The yolk sac persists throughout the greater part of embryonic life, and the yolk is taken directly from it into the alimentary canal. But the chief source of nutriment for the embryo is a creamy albuminous fluid secreted by vascular filaments which clothe the uterine wall of the mother so closely that they appear like coarse fur. Seemingly this secretion, squeezed out by the superficial musculature of the filaments, is taken in through the embryonic spiracles, into which the maternal filaments have been found inserted in some cases; it is absorbed along the digestive tract, and clots of it have been found within the spiral valve of the embryonic intestine.[12]

Habits. Sting Rays are seen (or caught) most commonly lying on the bottom on the flats of bays, shoal lagoons and river mouths or on patches of sand between coral heads, etc. Often they are partially buried in the mud or sand with only a portion of the tail, eyes, and spiracles exposed. It is chiefly by excavating the bottom with their pectoral fins that they obtain the worms, mollusks or crustaceans on which they feed; such hollows in the sand are familiar spectacles when they are exposed at low tide in regions of the tropics where Sting Rays abound, as in Australian waters.[13] They also succeed in capturing small fish in greater or lesser numbers. On the other hand, they often fall prey to large Sharks, and it is not unusual to find a Sting Ray spine imbedded in a Shark's mouth. It has been observed that an Indian species (*Dasyatis kuhlii*), while buried in the sand, utilizes the inner posterior margin of the spiracle to form a pro-

of the terminal portion of the spine where the venomous tissue is situated, but only that of the basal part of the spine, and of the tail itself beneath the free portion of the spine.

10. *Dasyatis centroura* of the western Atlantic (p. 352), *D. aspera* of the eastern Atlantic, and *D. brevicaudata* of New Zealand and Australia.

11. Whitley, Fish. Aust., 1, 1940: 201.

12. Knowledge of the embryonic nutrition of Sting Rays is due chiefly to a series of observations by Alcock (J. Asiat. Soc. Beng., *59* [2], 1890: 51; Ann. Mag. nat. Hist., [6] *9*, 1892: 417); and by Alcock and Wood-Mason (Proc. roy. Soc. Lond., *50*, 1891: 202). See also Gill (Smithson. misc. Coll., *52*, 1909: 173); and Southwell and Prashad (Rec. Indian Mus., *16*, 1919: 240), and Ranzi (Pubbl. Staz. zool. Napoli, *13*, 1934: 398) for a general survey, with references, and for a photograph of the inner uterine wall of the Mediterranean *Dasyatis violacea*.

13. For an excellent photograph showing the flats dotted with these hollows in North Queensland, see Whitley (Fish. Aust., *1*, 1940: 198, fig. 224).

jecting fold which is expanded when the water is agitated, thus protecting the spiracular opening from sand, etc. Normally, however, the spiracles are open in respiration for the intake of water, which is expelled via the gill openings, as in the case of Skates.[14]

Though lying quiescent for a large proportion of the time, Sting Rays are active swimmers on occasion, progressing rapidly by undulating motions of the margins of the pectorals much as Skates do. When on migration, or at other times for reasons not evident, they swim at the surface or plane along the latter.

Numerical Abundance. We have found no precise information as to the numerical abundance of Sting Rays anywhere. It is common knowledge, however, that in suitable localities in tropical coastwise waters they occur in such great plenty that it may seem as though the bottom were almost paved with them.

Relation to Man. Sting Rays of one sort or another are often offered for sale in the fish markets of tropical ports, the thicker parts of their discs alone being utilized. Their fins are used to some extent for gelatine and their liver-oil "is scarcely distinguishable in appearance or composition from cod-liver oil,"[15] but we are not aware that its vitamin content has been measured.

The spines of Sting Rays are such effective weapons that their use for tipping spears, either singly or several bundled together, was once fairly common practice in the Malay-Siam region, in New Zealand, among the island groups of the tropical and subtropical Pacific, and in Central and South America; in fact, they are still used by the aborigines of northern Australia.[16] In the Carolines they were used on daggers.[17] They have been used also as needles or as awls. In Central America, at localities well inland, they have been found in burial sites in numbers so great as to suggest that they were a regular article of trade.[18] In Malaya, too, they have been employed as a poison,[19] and along the Congo in tropical West Africa whips were made from the thorny tails of an African Sting Ray, and perhaps they still are.[20] Pieces of the spiny skins of Rays (genus *Urogymnus*), sewed with coconut fibre around sticks of wood 6–10 inches long, were used by the natives of the Gilbert group "so to shape the boards of their canoes that when sewed together they were watertight;"[21] however, this practice has now been replaced by the use of steel rasps. The skins of other smoother Rays have been employed for drum heads. On the debit side, Rays do more or less damage to cultivated oysters in Cavite Bay, Luzon, Philippines; at high tide they swim over the bamboo stakes that surround the beds and crack "open the oysters so that only halves of oyster shells cemented to the stakes remain."[22] And the inroads that they make on the local shellfish beds elsewhere must be great in regions where they are abundant. Also, they

14. Raj, Rec. Indian Mus., *10*, 1914: 317.
15. Donovan, Trans. Proc. N. Z. Inst., *52*, 1920: 29.
16. See Whitley (Fish. Aust., 1, 1940: 193, fig. 222) for distribution of Australian Sting Ray spears.
17. The late Sir P. H. Buck informed us that there is a dagger from the Carolines, with two Sting Ray spines, in the Bishop Museum, Honolulu, T. H.
18. Lothrop, Peabody Mus. Mem., 7, 1937: 97–98; Merwin and Vaillant, Peabody Mus. Mem., *3*, 1932: 90; Kidder, Amer. Antiquities, *2* (2), 1945: 68, footnote.
19. Gimlette, Malay Poisons, ed. 1923: 117.
20. Whitley, Fish. Aust., 1, 1940: 194.
21. See Walcott (Occ. Pap. Bishop Mus. Honolulu, *1* [2], 1900: 32) for description and photographs.
22. Villadolid and Villaluz, Philipp. J. Sci., *67*, 1938: 394.

are objects of concern to fishermen and to anyone else wading in the shallow water in regions where they are likely to be encountered, because wounds by their tail spines are followed almost immediately by excruciating pain,[23] by severe swelling, by violent muscular cramps, and often by subsequent inflammation and gangrene. Even fatalities have been reliably recorded.[24] Ordinarily recovery follows without any serious complications, but in any case the mechanical damage to tissues incident on the extraction of the spine is likely to be considerable because of its many-barbed structure.

Range and Bathymetric Distribution. The Whip-tailed Sting Rays are primarily a warmwater group; many of them are confined strictly to tropical-subtropical latitudes the year round; some are resident along warm-temperate coasts, and others carry out more or less regular and extensive migrations to higher latitudes with the vernal rise in sea temperatures, withdrawing again to warmer waters with autumnal cooling. Most of the Sting Rays are confined to shallow coastwise waters; in many parts of the world they commonly follow the rising tide onto mud- and sand-flats to retreat again on the ebb. Some occur commonly in the shoal channels and lagoons among the mangroves on tropical coasts, and some run up into fresh water. But others are known to occur as deep as 20–60 fathoms, possibly deeper.[25]

Genera. One member of the family is set apart so sharply from all others by its lack of tail spines that recent students generally refer it to a separate genus, *Urogymnus* Müller and Henle 1837. A second group, consisting of a few species that are characterized by the possession of a broad fold extending along the lower surface of the tail to the tip, constitutes a second well marked genus, *Taeniura* Müller and Henle 1837. A separate genus, *Urolophoides* Soldatov and Lindberg 1930, seems also needed provisionally for an East Asian Ray that has a tail spine, an upper caudal fold but seemingly no lower caudal fold, and a tail much shorter than the disc; unless, indeed, the unique specimen that served as the basis for the description had been mutilated (see p. 340, footnote 29). Opinions have differed, however, as to whether the 30 or more remaining members of the family, with long whiplash tails armed with spines and with longitudinal caudal folds (if any) terminating far short of the tip of the tail, are all referable to a single genus or whether the differences in degree of development of caudal folds and ridges deserve generic or subgeneric recognition.[26] On the basis of our own ex-

23. See Bassler (Science, *96*, 1942: 274) for a recent eye-witness account of the agonizing effects of a wound inflicted on a man's foot by the tail spine of one of the closely allied River Rays (*Potamotrygonidae*) of the Amazon.

24. Thus Schomburgk (Reisen Brit. Guiana, 1840–1844, *2*, 1848: 37–38) wrote that during his stay in British Guiana a laborer who was struck by a Sting Ray died in convulsions; Crevaux (Arch. Méd. nav., 1882: 37), quoted by Gudger (Bull. Hist. Med., *14*, 1943: 478), reported that a companion on the Orinoco died in 1881 from a wound by one of the river Rays; Vellard (Mém. Soc. zool. Fr., *29*, 1932: 514–532) speaks of fatalities as sometimes occurring from wounds by Sting Rays in Brazil. And Whitley (Fish. Aust., *1*, 1940: 198) quotes the case of a bather's death following the direct penetration of the heart, almost certainly by a Sting Ray spine.

25. Whitley (Fish. Aust., *1*, 1940: 201) states that the Australian *Dasyatis brevicaudata* is taken most often in 20–60 fathoms.

26. Barnard (Ann. S. Afr. Mus., *31* [1], 1925: 75) and Rey (Fauna Iberica, Peces, *1*, 1928: 620) refer all members of this group to a single genus. On the other hand, Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 375) distributed them among four named "groups" within the genus *Dasybatus*, which Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 403) ranks as subgenera of the genus *Dasyatis*. However, Jordan, Evermann and Clark (Rep. U. S. Comm. Fish. [1928], 2, 1930: 21) dignify the three groups that they mention (*Pastinachus*, *Dasyatis*, *Amphotistius*)

amination of a considerable series, we conclude that the most workable subdivision of the group of species in question is as follows: (a) those in which the tail bears neither membranous folds nor well marked longitudinal ridges either above or below (genus *Himantura*), and (b) those in which there is a membranous fold on the lower surface of the tail, with or without a fold or ridge above (genus *Dasyatis*).

Key to Genera

1a. No spine on tail. *Urogymnus* Müller and Henle 1837.[27]
Australia, East Indies, Indian Ocean, Red Sea.

1b. Upper surface of tail with a large serrated spine (or spines).

2a. Lower tailfold extending to tip of tail. *Taeniura* Müller and Henle 1837.
Red Sea, Indian Ocean south on African Coast to Delagoa Bay,[28] East Indies, Philippines, Australia, Polynesia; also Mediterranean and Cape Verde Islands.

2b. Lower tailfold either lacking or terminating far short of tip of tail.

3a. Tail shorter than disc. *Urolophoides* Soldatov and Lindberg 1930.
Peter the Great Bay, Northeast Asia; doubtful genus.[29]

3b. Tail longer (usually much longer) than disc.

4a. Lower surface of tail, posterior to spine, without membranous fold, either rounded or at most with a low cutaneous ridge.
Himantura[30] Müller and Henle 1837, p. 389.

4b. Lower surface of tail posterior to origin of spine with a longitudinal membranous fold. *Dasyatis* Rafinesque 1810, p. 340.

Genus *Dasyatis* Rafinesque 1810

Dasyatis Rafinesque, Carratt. Gen. Spec. Sicil., 1810: 16; type species, *D. ujo* Rafinesque, Sicily, equivalent to *Raja pastinaca* Linnaeus 1758.[31]

with the rank of full genera, and Whitley (Fish. Aust., 1, 1940: 200–208) recognizes four genera of long-tailed Rays with tail spines but without definitions.

27. *Urogymnus* Müller and Henle 1837 is antedated by *Anacanthus* Ehrenberg 1833 (in Van der Hoeven, Handb. Dierkunde, *2*, 1833: 179), but this name was preoccupied by Gray 1831 for teleost fishes and by Audinet-Serville 1832 for Coleoptera. To replace *Anacanthus* for the genus of Rays in question, Cantor (Malay. Fish., 1849: 1404) proposed *Rhachinotus*, which was accepted by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 373) in spite of the fact that the older name *Urogymnus* Müller and Henle 1837 (Arch. Naturg., *3*, 1837: 437) was expressly based on the same species (*Raja asperrima* Bloch and Schneider 1801) that was later christened *Rhachinotus africanus* by Cantor. The name *Urogymnus* was revived by Ogilby (Mem. Qd. Mus., *5*, 1916: 88) and has been used by subsequent writers generally.

28. Reported from Delagoa Bay by Smith (Sea Fish. S. Afr., 1949: 70).

29. The original and only account of this Ray (Soldatov and Lindberg, Bull. Pacif. Sci. Fish. Inst., *5*, 1930: 24), from a mounted specimen, records an upper tailfold but fails to state whether or not there was a lower tailfold. The account of the tail as stout with blunt tip leaves open the possibility that its shortness (only about $^4/_5$ as long as the disc) may have been due to mutilation, followed by subsequent healing of the wound; specimens with tails in this state are often seen among other species of Sting Rays.

30. *Himantura* was proposed by Müller and Henle (Arch. Naturg., 3 [1], 1837: 400) with diagnosis but without mention of any particular species. Duméril (Hist. Nat. Poiss., *1*, 1865: 585), however, referred a considerable list of species to it, including *Raja uarnak* Forskål 1775, which was later designated as the type species by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 375).

31. Besides the synonyms listed here, Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 402) includes the fossil genera

Generic Synonyms:

Raja (in part) Linnaeus, Syst. Nat., *1*, 1758: 232; for *R. pastinaca* Linnaeus. Europe.

Uroxis Rafinesque, Indice Ittiol. Sicil., 1810: 48; type species, *Dasyatis ujo* Rafinesque, Sicily, equivalent to *Raja pastinaca* Linnaeus 1758.

Trygonobatus (in part) Blainville, Bull. Soc. philom. Paris, 1816: 112; includes *Raja sephen* Forskål 1775. Red Sea.[32]

Trygon Cuvier, Règne Anim., *2*, 1817: 136; type species, *Raja pastinaca* Linnaeus 1758, designated by Jordan (Genera Fish., 1, 1917: 98).

Trygonobatis Blainville, in Vieillot, Faune Franç., Poiss., 1825: 35; type and only described species, *Raja pastinaca* Linneaeus 1758. East Atlantic.

Pastinachus Rüppell, Atlas Reise nördl. Afr., *2*, Fische Rothen Meeres, 1828: 51, footnote; type species, *Raja sephen* Forskål 1775, Red Sea, designated by Jordan (Genera Fish., *1*, 1917: 122).[33]

Trigon (in part) Rüppell, Atlas Reise nördl. Afr., Fische Rothen Meeres, Abt. 1, 1828: 51; includes *Raja sephen* Forskål 1775.

Hypolophus (subgenus) Müller and Henle, Arch. Naturg., *1*, 1837: 400; no species named; but *Raja sephen* Forskål 1775 included as example by Bonaparte (Nuov. Ann. Sci. Nat. Bologna, *2*, 1838: 202, and Mém. Soc. Neuchâtel Sci. Nat., 2 [7], 1839: 6) and designated as type species by Jordan (Genera Fish., *2*, 1919: 193).

Pastinaca Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1838: 192, 319; type species, *P. olivacea* Swainson, equals *Raja pastinaca* Linnaeus 1758.

Hemitrygon (subgenus) Müller and Henle, Charlesworth Mag. Nat. Hist., *2*, 1838: 90; no species mentioned; type species, *Trygon bennetti* Müller and Henle 1841, designated by Jordan (Genera Fish., *2*, 1919: 190).

Dasibatus L. Agassiz, Nom. Zool. Pisc., 1845: 21; emended spelling for *Dasybatus* Klein 1775; see p. 341, footnote 34.

Dasybatis Jordan and Gilbert, Proc. U. S. nat. Mus., *3*, 1880: 31; type species, *D. dipterurus* Jordan and Gilbert. San Diego, California.

Dasybatus Jordan and Gilbert, Proc. U. S. nat. Mus., *4*, 1881: 35; for *Dasybatis dipterurus* Jordan and Gilbert 1880;[34] Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 375; by ref. to *Dasybatus* Klein 1775 and Walbaum 1792.

Dasibatis Garman, Bull. U. S. nat. Mus., 16, 1883: 68; type species, *Raja pastinaca* Linnaeus 1758; alternative spelling for *Dasybatis* Jordan and Gilbert 1880.

Taeniura Macleay, Proc. Linn. Soc. N. S. W., *7*, 1883: 598; for *T. atra* Macleay, equals *Raja sephen* Forskål 1775.

Dasabatis Evermann and Kendall, Bull. U. S. Fish Comm., *12*, 1894: 95; type species, *Raja say* Lesueur 1817; emended spelling for *Dasibatis* Garman 1883 or for *Dasybatis* Jordan and Gilbert 1880.

Pteroplatytrygon (subgenus) Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 474; type species, *Trygon violacea* Bonaparte 1832.

Amphotistius (subgroup) Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 375, 392; type species, *Trygon sinensis* Steindachner 1892, designated by Jordan, Evermann and Clark (Rep. U. S. Comm. Fish. [1928], *2*, 1930: 28).

Heliobatis Marsh (Amer. J. Sci., [3] *14*, 1877: 256) and *Xiphotrygon* Cope (Amer. Nat., *13*, 1879: 333). But while the latter certainly (and the former probably) falls among the long-tailed Sting Rays, it is doubtful whether either of them was actually congeneric with the modern *Dasyatis*.

32. This is the only identifiable species among the nine that were included by Blainville in the subdivision of his genus *Pastinachus* with a fold on the lower surface of the tail. Jordan's (Genera Fish., *1*, 1917: 94) designation of *Raja pastinaca* Linnaeus 1758 as the type cannot be accepted because this name was not included in Blainville's list of species for either subdivision of his *Trygonobatus*.

33. The term "Pastinachae," applied by Nardo (Prod. Ittiol. Adriat., Giorn. Fisica Pavia, *1*, 1827: 8) to his "Sect. I" of *Raja* and for which Jordan (Genera Fish., *1*, 1917: 121) designated a type species (*Raja pastinaca* Linnaeus 1758), does not come into consideration as a generic name since it is not binomial.

34. The name *Dasybatus* had been employed for Sting Rays previously by Klein (Neuer Schauplatz, 1775: 991) and by Walbaum (P. Artedi Genera Pisc. Emend. Ichthyol., *3*, 1792: 581). But the International Commission on Zoological Nomenclature has ruled that neither Klein's generic names nor Walbaum's republication of them are available. *Dasybatus* Blainville 1816 and *Dasybatis* Blainville 1825 (see Synonyms, p. 138) are equivalents of *Raja* Linnaeus 1758 and not of *Dasybatus* Klein 1775.

Pastinachus (subgroup) Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 375; type species, *Raja pastinaca* Linnaeus 1758.

Bathytoshia Whitley, Rec. Aust. Mus., *19*, 1933: 61; type species, *Dasyatis thetidis* Waite 1899, New South Wales, probably equals *Trygon lata* Garman (Bull. Mus. comp. Zool. Harv., *6*, 1880: 170).[35]

Toshia Whitley, Rec. Aust. Mus., *19*, 1933: 60; type species, *Dasyatis fluviorum* Ogilby 1908. Australia.

Neotrygon Whitley, Fish. Aust., *1*, 1940: 208; type and only included species, *Trygon kuhlii* Müller and Henle 1841. East Indies and India, also Philippines, South China, Australia, and western tropical Pacific.

Probable Synonym:

Neotrygon Castelnau, Proc. Zool. Acclim. Soc. Victoria, *2*, 1873: 122; type species, *N. trigonoides* Castelnau.[36]

Not *Dasybatus* Blainville, Bull. Soc. philom. Paris, 1816: 112; equals *Raja* Linnaeus 1758, which see, p. 138.

Not *Dasyatis* Blainville, in Vieillot, Faune Franç., Poiss., 1825: 12; equals *Raja* Linnaeus 1758, which see, p. 138.

Not *Dasibatis* L. Agassiz, Nom. Zool. Pisc., 1845: 21; emended spelling for *Dasybatis* Blainville 1825.

Not *Pastinachus* Rüppel, Neue Wirbelt. Abyssinia, *4*, Fische, 1835: 69; equals *Himantura* Müller and Henle 1841, which see, p. 389.

Generic Characters. Tail much longer than disc, with a large serrate-edged spine (or spines) above; its lower surface, close posterior to spine, with a well developed longitudinal dermal fold, its upper surface either with a corresponding fold (usually lower), or with a recognizable ridge,[37] or merely rounded. Teeth small and numerous, closely crowded in quincunx in both sexes; those of females and of young males low, rounded, or nearly flat, often worn in more or less distinct ridges; those of sexually mature males with conical cusp in some species, perhaps in all.[38] Upper tooth band strongly convex in cross section, the lower weakly so; both bands moderately broad centrally, narrowing toward corners; 6 or 7 to 10 or 12 rows of teeth exposed and in function simultaneously along different parts of jaws. Pelvis without median process, so far as known. Characters otherwise those of the family.

Remarks. The genus, as here defined, corresponds to the subgenera *Pastinachus*, *Dasyatis*, and *Amphotistius* combined, of Garman and of Fowler.[39]

Size. This genus includes the largest known Sting Rays, namely *Dasyatis brevicaudata* (Hutton) 1875 of New Zealand and Australia, *D. aspera* (Cuvier) 1817 of the Mediterranean, Madeira, and tropical West Africa, and *D. centroura* (Mitchill) 1815 of the western North Atlantic (p. 352).

Range. Tropical-subtropical coastlines in general. In the Atlantic, representatives of *Dasyatis* occur from tropical West Africa to the North Sea, Skagerrak, and western Baltic in the east; from Uruguay to southern New England in the west.

35. The specimen, originally in the Harvard Museum of Comparative Zoology and from which Garman described this species, is no longer to be found.

36. Castelnau states that his *trigonoides* from New Caledonia, for which he proposed the genus *Neotrygon*, has tail folds above and below ("dorsal" and "anal" fins) but no tail spine. But Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 426) has relegated *trigonoides* to the synonymy of *Dasyatis kuhlii* (Müller and Henle, 1841), which has well developed spines. If this allocation be correct, as appears to be the case, *Neotrygon* Castelnau 1873 is clearly a synonym of *Dasyatis* Rafinesque 1810, as defined here, as is *Neotrygon* Whitley 1940.

37. In preserved specimens this ridge sometimes becomes so obscured, perhaps through muscular contraction, that the upper surface of the tail behind the spine is merely arched or simply rounded.

38. The transition from the flat or rounded teeth in older (anterior) rows to cuspidate teeth in younger (more posterior) rows may often be seen on males nearing sexual maturity.

39. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 373) termed them subgroups; Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 404), subgenera.

Species. Recent surveys of the genus, as here defined, for various parts of the world recognize a total of some 30 species.[40] But it is likely that a general revision would result in a considerable reduction in this number. Six species are known from the western Atlantic (see Key, p. 343).

The representatives of *Dasyatis* and of *Himantura* in the western Atlantic are more readily identifiable by the proportionate dimensions of disc and tail and by the shape of the disc than they are by the degree of development of the longitudinal ridges or folds on the tail, though these last characters are more significant from the generic standpoint. The local members of the two genera are therefore grouped together in the following Key for convenience in identification.

Key to North Atlantic, Western South Atlantic and Tropical West African Species of *Dasyatis* and *Himantura*[41]

1a. Anterior contour of median sector of disc either a uniform arc of long radius or nearly straight.

2a. Distance from center of cloaca to origin of tail spine nearly as long as distance from center of cloaca to tip of snout; entire upper surface of disc closely clothed with small tubercles; tail without folds above or below.

Himantura schmardae (Werner) 1904, p. 390.

2b. Distance from center of cloaca to origin of tail spine much shorter than distance from cloaca to snout; upper surface of disc mostly naked; lower surface of tail with well developed longitudinal cutaneous fold.

Dasyatis violacea (Bonaparte) 1832.
Mediterranean.

1b. Anterior contour of median sector of disc subangular, with tip of snout forming the apex.

3a. Entire upper surface of disc rough with minute dense asperities.

Dasyatis rudis (Günther) 1870.
Old Calabar, Equatorial West Africa.[42]

3b. Upper surface of disc mostly smooth except along median belt, and here or there elsewhere.

4a. Distance from level of axils of pectorals to origin of tail spine about as long as distance from level of axils of pectorals to rear margins of orbits; center of back with a single large white tubercle.

Dasyatis margarita (Günther) 1870.
Tropical West Africa.

40. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 381, 388, 392; Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 125; Bull. U. S. nat. Mus., 100 (*13*), 1941: 413, 420, 421.

41. China and Trinidad are given as localities for *Dasyatis bennetti* by Müller and Henle (Plagiost., 1841: 160), its describers. But recent authors have restricted the name to the Pacific form, hence it is not included in the Key. For references, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 413).

42. Günther, Cat. Fish. Brit. Mus., *8*, 1870: 479. Thus far *D. rudis* appears to be known from the original account only, which was based on a single large specimen $6\frac{1}{2}$ feet broad. A more detailed account of this species is much to be desired, especially as regards its tailfolds, if any.

4b. Distance from level of axils of pectorals to origin of tail spine considerably shorter than distance from level of axils of pectorals to rear margins of orbits; center of back without a single large white tubercle.

5a. Outer corners of disc broadly and evenly rounded.

6a. Pelvic fins with narrowly pointed outer corners, their anterior margins about 2.5 times as long as distance between outer margins of orbits. *Dasyatis geijskesi* Boeseman 1948, p. 363.

6b. Pelvic fins with broadly rounded outer corners, their anterior margins little, if any, longer than distance between outer margins of orbits.

7a. Snout anterior to orbits considerably longer than distance between spiracles; anterior contour of disc concave on either side of tip of snout.

Dasyatis sabina (Leseuer) 1824, p. 370.

7b. Snout anterior to orbits shorter than distance between spiracles; anterior outlines of disc weakly convex on either side of tip of snout. *Dasyatis say* (Leseuer) 1817, p. 378.

5b. Outer corners of disc only narrowly rounded or abruptly subangular.

8a Anterior margins of disc continuously though weakly concave anterior to level of posterior margins of spiracles; tip of snout projecting from general contour in subtriangular outline (Fig. 86).

9a. Posterior parts of pelvics extending rearward beyond posterior limits of pectorals for a distance as great as longitudinal diameter of spiracle; disc naked except for tubercles along midline of back and on shoulders of large specimens.

Dasyatis pastinaca (Linnaeus) 1758.
Eastern North Atlantic to North Sea, Skagerrak and western Baltic; Mediterranean; south to South Africa; also reported from India and East Africa south to Agulhas Bank.[43]

9b. Posterior parts of pelvics extending only very little rearward beyond level of posterior limits of pectorals; midbelt of disc, rearward from interocular region, densely clothed with small rounded tubercles on half-grown and larger specimens.

Dasyatis guttata (Bloch and Schneider) 1801, p. 365.

8b. Anterior margins of disc nearly straight, or at most weakly sinuous, anterior to level of posterior edges of spiracles; tip of snout not projecting conspicuously from general anterior contour (Figs. 81, 83).

43. It is not yet certain whether the Ray reported under this name from the Indian Ocean is identical with *D. pastinaca* of the Mediterranean and eastern Atlantic.

10a. A longitudinal cutaneous fold along lower side of tail about as wide as height of tail; upper surface of tail with a low longitudinal ridge close posterior to spine, or at least arched in cross section; sides of tail without conspicuous tubercles.

Dasyatis americana Hildebrand and Schroeder 1928, p. 345.

10b. A longitudinal cutaneous fold along lower side of tail only about half as wide as height of tail; upper surface of tail posterior to spine rounded, without longitudinal ridge; sides of tail, in half-grown specimens and larger, rough with conspicuous tubercles or thorns.

Dasyatis centroura (Mitchill) 1815, p. 352, and *Dasyatis aspera* (Cuvier) 1817.

Eastern Atlantic, tropical West Africa, Madeira, and Mediterranean.[44]

Dasyatis americana Hildebrand and Schroeder 1928

Figures 81, 82

Study Material. Fifteen specimens, 126–525 mm wide, including embryos, from Brazil, Trinidad, Puerto Rico, Cuba, Bahamas, Gulf of Campeche, Yucatán, Texas, Florida, and Chesapeake Bay, in Museum of Comparative Zoology and U. S. National Museum.

Distinctive Characters. *D. americana*, regardless of size, is separable at a glance from *D. sabina*, *D. guttata* and *Himantura schmardae* by the shape of the anterior part of its disc (cf. Fig. 81 with 86, 88, 93). It is separable from *H. schmardae* also by the position of its spine well forward on the tail (cf. Fig. 81 with 93). It is distinguished further from *D. guttata* by the fact that the armature on the dorsal crest of its disc on either side of the midline of tubercles consists only of minute prickles. If the tail is intact, *D. americana* has only a low ridge on its upper surface, whereas *D. say* has a well developed fold there. Specimens of *D. americana* that have lost their tails are separable from *D. say* by the fact that both the outer and the posterior corners of their discs are much more abrupt than those of the latter (cf. Fig. 81 with 90). The relatively great breadth of the lower tailfold of *D. americana* (cf. Fig. 81A with 83A), plus the presence of a ridge or keel on the upper surface of the tail posterior to the spine, marks it off from *D. centroura*. Apart from the size, a tailless *D. americana*, prior to the appearance of the mid-dorsal thorns, resembles a young *D. centroura* so closely that we have been unable to find any dependable criteria by which to distinguish the one from the other. Even so, the danger of confusing them is small, for *D. centroura*

44. It is still an open question whether or not *D. centroura* of the western Atlantic and *D. aspera* of the eastern are separable; for discussion, see p. 357.

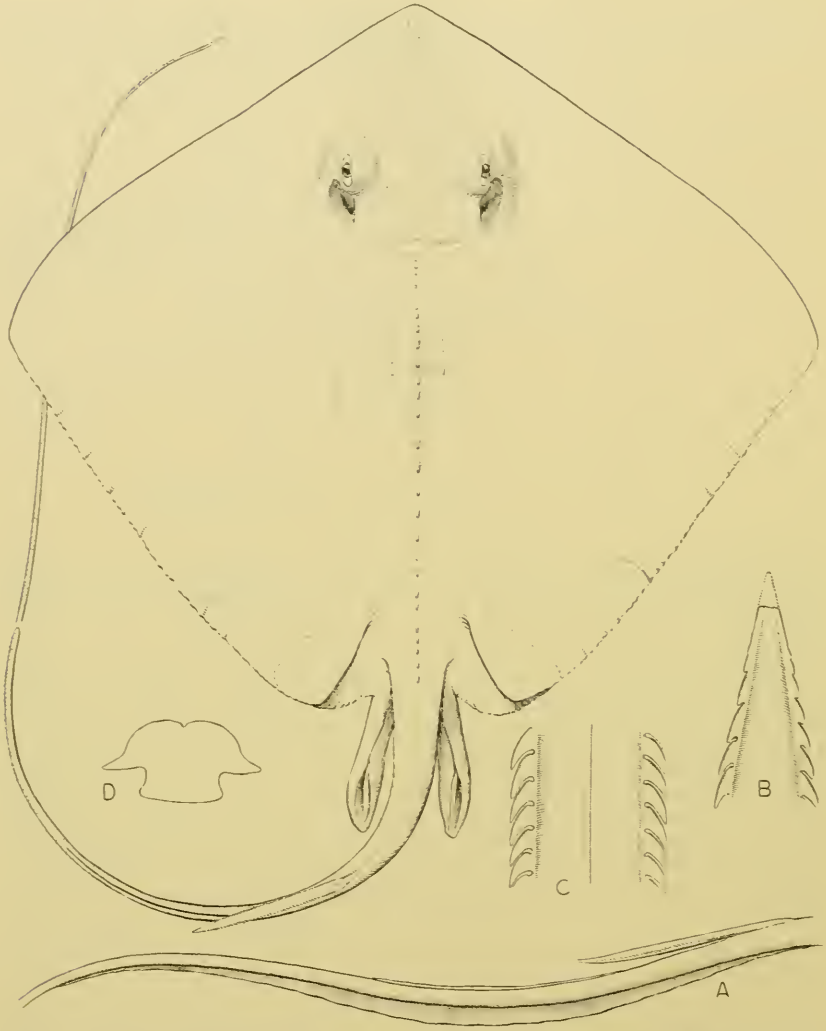


FIGURE 81. *Dasyatis americana*, male, 505 mm wide, from Molasses Key, Florida (Harv. Mus. Comp. Zool., No. 367). *A* Side view of midsector of tail to slightly larger scale. *B* Tip of tail spine, about 3.9×. *C* Midsector of tail spine, about 3.9×. *D* Cross section of tail spine about midway of its length, about 3.9×.

still is smooth-skinned to a size considerably greater than that at which *D. americana* commences to show its characteristic mid-dorsal thorns.

Description. Proportional dimensions in per cent of extreme breadth of disc. Male, 364 mm broad, from Key West, Florida (U. S. Nat. Mus., No. 125797). Female, 527 mm broad, from Pernambuco, Brazil (Harv. Mus. Comp. Zool., No. 246).

Disc: vertical length 86.2, 85.5.

Snout length: in front of orbits 18.4, 17.1; in front of mouth 20.3, 18.6.

Orbits: horizontal diameter 8.0, 5.7; distance between 9.3, 8.0.

Spiracles: length 7.1, 5.3; distance between 17.0, 14.2.

Mouth: breadth 8.2, 8.9.

Exposed nostrils: distance between inner ends 10.7, 10.4.

Gill openings: lengths, 1st 3.0, 2.7; 3rd 3.0, 2.7; 5th 2.3, 1.9; distance between inner ends, 1st 18.6, 19.4; 5th 11.4, 11.9.

Pelvics: anterior margin 17.0, 15.6.

Distance: from tip of snout to center of cloaca 78.8, 74.1; from center of cloaca to origin of caudal spine 37.1, 33.8.

Disc about 1.2 times as broad as long (specimens 15 to 60 in. wide), rhomboid; tip of snout subangular, projecting at most only a little or not at all; maximum anterior angle in front of spiracles about 135°; anterior margins varying from nearly straight to slightly concave or weakly convex anterior to level of eyes, becoming increasingly convex toward outer corners, the latter being either abruptly rounded or subangular; posterior margins nearly straight anteriorly but becoming weakly convex posteriorly; posterior corners abrupt, much as in *D. centroura*; inner posterior margins straight or weakly convex. Axis of greatest breadth about 38–40 % of distance rearward from tip of snout toward rear limits of disc. Tail moderately depressed dorsoventrally and evenly rounded laterally anterior to spine; its upper surface posterior to spine with a low fleshy keel extending rearward nearly or quite as far as rear termination of lower tailfold on most specimens, but rounded on some;[45] lower surface of tail with a more or less conspicuous longitudinal fold originating about under origin of tail spine and extending rearward for a distance about 1.2–1.4 times as long as distance from axils of pectorals to spine; nearly uniformly wide throughout most of its length but narrowing at either end to merge with general contour of tail; its maximum width at spine about equal to or greater than height of tail on some large specimens, but only about half as high as tail on others and on embryos. Tail from center of cloaca 1.9 (small specimen) to 2.3 times as long (large specimen) as distance from center of cloaca to tip of snout, if not damaged; distance from origin of tail spine to center of cloaca about 45 % as long as distance from cloaca to snout.

Length of free portion of tail spine (one only on specimens seen) about as great as distance between outer margins of orbits; total length of spine from origin about 1.3 times that great; its lateral teeth 52 and 80 on each side in two specimens counted,[46] often covered with skin to tip even on large specimens.

45. We have examined one such specimen.

46. These spines were not damaged. The specimen whose tail spines had 52 teeth was 36 inches wide, the one with 80 teeth was 60 inches wide.

Midline of back with a row of ridge-like tubercles, truncate posteriorly, on smooth oval bases; partly-grown specimens (375–425 mm wide) with about eight of these from nuchal region rearward, followed next by a considerable gap, then by two or three tubercles close in front of tail or on its base; mature specimens with the median row numbering 30 or more,[47] continuous or nearly so though irregularly spaced; each shoulder also developing a longitudinal series of smaller tubercles, from 2–3 at first

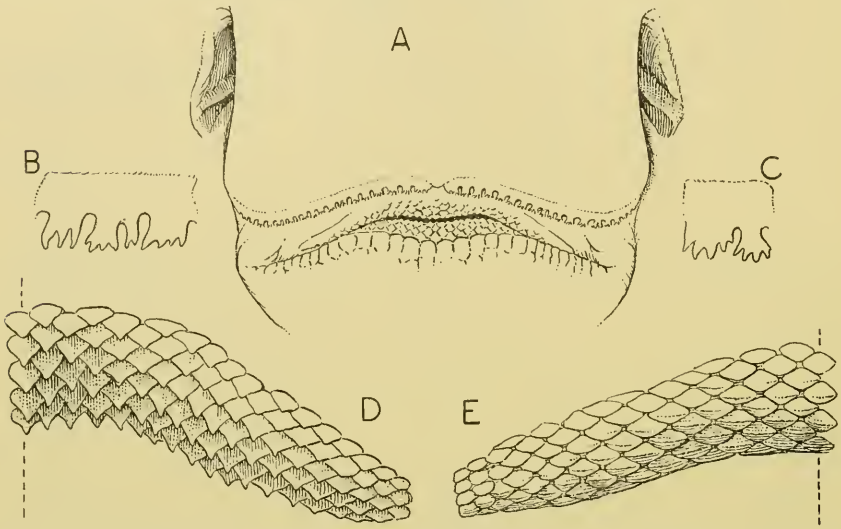


FIGURE 82. *Dasyatis americana*. *A* Nostrils, nasal curtain and mouth of male pictured in Fig. 81. *B* Detail of margin of nasal curtain from right-hand side, about 1.3×. *C* Detail of margin of nasal curtain from left-hand side, about 1.3×. *D* Left-hand half of upper tooth band, about 3.3×. *E* Right-hand half of upper tooth band of female, 448 mm long, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 571), about 3.3×.

to 10–12 at maturity; both medians and scapulars larger and more conspicuous on females than on males; areas between orbits and between spiracles sparsely prickly on males by maturity, more densely so on females, also prickly on nuchal and scapular regions; a belt along either side of the median row of tubercles more or less prickly on medium-sized specimens (about 40 in. wide), the largest (about 60 in. wide) with prickles covering entire disc; upper and lateral surfaces of tail close in front of spine and posterior to it rough with prickles on large specimens, but smooth farther forward; pelvics smooth in both sexes. Lower surface smooth on disc and on tail anterior to spine.

Snout in front of orbits about as long as distance between outer edges of orbits, its length in front of mouth 1.8–2.0 times as great as distance between exposed nostrils

47. Sixty have been reported for a Cuban specimen (1,058 mm wide) that may have been of this species, by Fowler (Fish Culturist, *21*, 1942: 66 as "*Dasyatis scabrata*"); see also p. 352, footnote 64.

and about equal to distance between inner ends of first gill openings. Eye about 75–85 % as long as distance between eyes and about equal to length of spiracle. Distance between inner ends of first gills about 1.7–1.9 times as long as distance between exposed nostrils; distance between inner ends of fifth gills about 62 % as great as that between inner ends of first gills. Free posterior margin of nasal curtain weakly concave, fringed, the individual lobes simple or variously divided, those of the two sides separated in midline by a narrow gap. Mouth with upper jaw moderately projecting centrally and lower jaw moderately recessed, a little more so on mature males than on females. Floor of mouth, centrally, with a transverse series of three stout papillae, sometimes with another more slender papilla on one side or on both sides.

Teeth $\frac{39}{39}$ to $\frac{56}{56}$,[48] about equally large all along each tooth band except for somewhat smaller ones near outer corners; those of females and immature males tetragonal with rounded corners, a little broader (transversely) than long (anteroposteriorly), the functional surfaces weakly rounded or flat, often scored; those of sexually mature males with low conical cusp; 6–8 rows in function simultaneously in upper jaw and about 12 rows in lower jaw near center but only 8–9 rows near outer corners.

Anterior margins of pelvics nearly straight on small specimens, usually more convex on larger; outer corners moderately rounded, the posterior corners usually more broadly rounded but varying widely in degree of curvature among large specimens; anterior margin of pelvic about as long as distance from its own origin to rear tip of longest ray of pelvic.

Color.[49] Upper surface of disc gray, dark or olivaceaous brown, or olive green, depending on the color of the bottom on which the Ray is lying; sometimes darker toward outer margins and narrowly edged with white; a gray or whitish spot on median line of snout close in front of eyes; sides of anterior part of tail grayish or whitish, its dorsal keel, ventral fold, and terminal portion black or brownish black. Lower surface of disc white or whitish with an edging of gray or brown, either solid or broken into irregular spots; inner posterior portions of pelvics so marked also. Tail spine described as dark on fresh specimens.

Size. Embryos nearly ready for birth are about 126 (see Study Material) to 170–180 mm broad, suggesting a width not far from 200 mm as usual at birth. It is probable that females may mature at a breadth of 750–800 mm, possibly smaller, for a North Carolina specimen 828 mm wide (33 in.) gave birth to three young on capture. Males may mature at a somewhat smaller size, for one about 510 mm wide (20 in.) has been reported as adult; furthermore, the claspers of another of about that same size are so large as to suggest the imminence of sexual activity. The largest specimens of *D. americana* positively recorded have been: 40, 42, 44, and 60 inches in width, all of these recently examined by us at Bimini, Bahamas. One about 37 inches wide from the Tortugas, Florida weighed 58 pounds.[50]

48. The smallest specimen which we counted, with disc 14 inches wide, had 39 series in each jaw; the largest, 60 inches wide, had 56.

49. We have no color notes from life.

50. Gudger, Aust. Mus. Mag., *6* (6), 1937: 208.

Developmental Stages. Embryos nearly ready for birth closely resemble their parents except that the lower tailfold is relatively narrower. A female gave birth to three young on capture.[51] Other females that gave birth to four or five, one of them also containing 15 eggs of various sizes, likewise have been referred to this species.[52] Nothing further is known of its breeding habits.

Habits. All recorded captures of this Ray have been from partially enclosed waters, or at least from close inshore. The fact that all dated records of it from North Carolina to New Jersey have been during the months of July, August and early September shows that it is a summer visitor to the northern part of its range. But reports of its northerly presence have not been numerous enough for us to establish the approximate dates of its vernal arrival or of its autumnal departure, or to afford a correlation between its migrations and the seasonal cycle of temperature.

The stomachs of Florida specimens[53] and of others collected near Beaufort, North Carolina, contained clams, blue crabs (*Callinectes*), shrimps, worms, and small bony fishes. Specimens which we opened at Bimini, Bahamas, contained stomatopods, shrimps, crabs, worms, and fish. Further information as to its way of life is confined to an observation among the Florida Keys that they are usually seen gliding in pairs close to the sandy bottom from which it is difficult to distinguish them, and that they swim away rapidly upon the approach of a small boat.[54] They are reported as being sometimes taken on hook and line as well as in seines on the bottom around Trinidad. And the fact that a specimen, referred to this species, towed a 22-foot launch for 15 minutes[55] illustrates the power with which the larger Sting Rays drive ahead when disturbed.

Numerical Abundance. No precise information is available as to its actual abundance anywhere except that it is common on the coasts of Mississippi and western Florida,[56] that 20 were taken in the vicinity of Beaufort, North Carolina, in 1936 between July 30 and August 16,[57] and that we saw five specimens brought in at Bimini by one fishing boat on one day in January 1949.

Relation to Man. Adult individuals, being even greater in size than *Dasyatis say*, are doubtless as great a menace as the latter to anyone handling or treading upon them, but no specific reports have been received of injuries inflicted by this particular Ray.

Range. Coastal waters of the western Atlantic, from Rio de Janeiro, Brazil to New Jersey.

Details of Occurrence. In early scientific literature *D. americana* was often confused with the larger *D. centroura* of more northerly habitat, and there are many published reports of its presence by name without any supporting evidence as to actual identity. Hence it is hazardous to define its distribution from the published record alone. Our Study Material, however, includes specimens from localities so distributed

51. Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: 274, pl. 46, fig. 3) shows mother and young.
52. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 338; Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 99.
53. Personal communication from Stewart Springer.
54. Fowler, Proc. Acad. nat. Sci. Philad., *58*, 1906: 80.
55. Gudger, Aust. Mus. Mag., 6 (6), 1937: 208.
56. Personal communication from Stewart Springer.
57. Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 99.

as to prove it widespread throughout the coastwise waters of the tropical-subtropical belt of the western Atlantic, including the Caribbean and Gulf of Mexico as a whole. Localities from which we have seen specimens include the following: Rio de Janeiro and Pernambuco in Brazil; Trinidad, Puerto Rico, Cuba and the Bahamas among the West Indies; Carmen, Gulf of Campeche and Progresso, Yucatán; Aransas Bay, Texas; Tampa in northwestern Florida and Molasses Key and Key West in southern Florida. And reports of it from the following are doubtless well founded also: Bahia, Brazil; British Guiana; Curaçao; the Grenadines; Barbados; St. Eustatius; Jamaica;[58] New Orleans, Louisiana; Mississippi;[59] the Tortugas, Marquesas Keys, Lemon Bay, and Salerno,[59] in Florida.

Its occurrence in some numbers in the general vicinity of Beaufort and Cape Lookout, North Carolina has long been established. However, it seems that *D. americana* does not range regularly or in any numbers much past Cape Hatteras, for extensive collecting by the U. S. Bureau of Fisheries in Chesapeake Bay resulted in the capture of only a single specimen,[60] while only two that can be referred to this species with reasonable certainty have been reported from farther north, namely from Delaware Bay and from Cape May, New Jersey.[61]

Synonyms and References:

Dasibatus hastatus Garman, Bull. U. S. nat. Mus., 16, 1883: 70 (descr., Rio de Janeiro, Pernambuco, Cuba, Florida; but name *hastatus* preoccupied by DeKay, 1842, for another Ray; see p. 361).

Trygon hastata Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, S. Atlant. and Gulf coasts, U. S., and W. Indies); Metzelaar, Trop. Atlant. Visschen, 1919: 7 (size, buccal papillae, teeth; St. Eustatius I., W. Indies); Bijdr. Dierk. K. Zool. Genoot. Amst., *22*, 1922: 136 (size, Curaçao).

Dasyatis (*Dasyatis*) *hastata* Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 83 (descr., W. Indies to Brazil and Florida); Rep. U. S. Comm. Fish. (1895), 1896: 223 (listed, Brazil, Florida, but Rhode Island ref. probably to *D. centroura* Mitchill 1815).

Dasyatis hastata[62] Jordan and Rutter, Proc. Acad. nat. Sci. Philad., [49], 1897: 93 (listed, Kingston, Jamaica); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (listed, Florida); Evermann and Marsh, Bull. U. S. Fish Comm., *20*, 1902: 65 (descr., Hucares, Puerto Rico); Bean, T. H., Bull. N. Y. St. Mus., 60, Zool. *9*, 1903: 54 (descr., but refs. only in part); Cole and Barbour, Bull. Mus. comp. Zool. Harv., *50*, 1906: 155 (Progresso, Yucatán); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 188, 210 (descr., Florida to Brazil, refs. in part); Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 338 (64-pound specimen with 5 embryos, C. Lookout, N. Carolina); Vincent, Sea Fish. Trinidad, 1910: 53 (listed, Trinidad); Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 160 (same specimen as in Coles, 1910); Yearb. Carneg. Inst. (1913), *12*, 1914: 177 (listed, Tortugas, Florida); Coles, Proc. biol. Soc. Wash., *28*, 1915: 93 (same specimen as in Coles, 1910); Fowler, Proc. Acad. nat. Sci. Philad., *67*, 1915: 521 (listed, Trinidad); Wilson, Proc. U. S. nat. Mus., *47*, 1915: 703 (copepod parasites, Montego Bay, Jamaica); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 146 (*centroura* of Fowler [Proc. Acad. nat. Sci. Philad., *61*, 1909: 408] actually this species; Delaware Bay); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 44 (same as Ribeiro, 1907); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn.); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 32 (descr., Somerset County, Maryland); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (in check list); Gudger,

58. Personal communication from Luis Howell-Rivero.

59. Personal communication from Stewart Springer.

60. Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 64; this specimen was the basis for the name *D. americana*.

61. A nominal report of 30–40 pound *hastata* from Ocean City, Maryland (Bean, Bull. U. S. Fish Comm., 7, 1888: 151) may also belong here. However, other reports of *hastata* from New Jersey, Rhode Island and Massachusetts doubtless referred to *Dasyatis centroura*, which regularly ranges farther northward (p. 360).

62. Sometimes spelled *hastatus*.

Copeia, 1933: 186 (Tortugas, Florida); Bere, Amer. Midl. Nat., *17*, 1936: 607 (copepod parasites, Lemon Bay, W. Florida); Gudger, Aust. Mus. Mag., *6*, 1937: 208 (size, strength, Tortugas, Florida); Hildebrand, Copeia, 1941: 222 (listed, N. Carolina); Fowler, Monogr. Acad. nat. Sci. Philad., *6*, 1944: 456 (listed, Jamaica); Monogr. Acad. nat. Sci. Philad., 7, 1945: 99, 161, 264 (weights, nos. embryos, N. Carolina, S. Carolina, Florida).

Dasybatus hastatus Fowler, Proc. Acad. nat. Sci. Philad., *58*, 1906: 81 (descr., size, habits, Marquesas Key, S. Florida); Rep. N. J. Mus. (1905), 1906: 77 (descr.); Rep. N. J. Mus. (1906), 1907: 261, pl. 79 (ill., but tailfold not shown); Radcliffe, Trans. Amer. Fish. Soc., *44*, 1914: 38 (listed, Beaufort, N. Carolina); Bull. U. S. Bur. Fish., *34*, 1916: 273, pl. 46 (descr., teeth, dermal armature, size, stom. contents, nos., female with embryos, photos, near Beaufort, N. Carolina); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 80 (descr.).

Dasyatis centroura Fowler, Proc. Acad. nat. Sci. Philad., *61*, 1909: 407–408 (Delaware Bay, subsequently refd. by Fowler [Proc. biol. Soc. Wash., *33*, 1920: 146] to *hastata*, equals *americana*).

Dasyatis say (in part) Fowler, Proc. Acad. nat. Sci. Philad., *92*, 1910: 473 (Delaware Bay specimens, subsequently refd. by Fowler [Proc. biol. Soc. Wash., *33*, 1920: 146] to *hastata*, equals *americana*).

Dasybatus (*Dasybatus*) *hastatus* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 391 (descr., but refs. only in part).

Dasyatis americana Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 64, fig. 35 (new name for *Dasibatus hastatus* Garman 1883; color, meas., photo of female and embryos from Radcliffe, 1916, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 35 (ill.); Nichols, Sci. Surv. Puerto Rico, N. York Acad. Sci., *10* (2), 1929: 186 (diagn., ill., tailfold not shown, Puerto Rico); Chamberlain, Copeia, 1934: 42 (mutilated by fishermen, S. Carolina); Beebe and Hollister, Zoologica N. Y., *19*, 1935: 209 (size, color, Union I., Grenadines, W. Indies); Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22 (color, size, temp., sal., Texas).

Probable Synonyms:

Trygon pastinaca (in part) Günther, Cat. Fish. Brit. Mus., *8*, 1870: 478 (N. America, "W. Indies," Barbadoes, New Orleans, Brit. Guiana, Bahia specimens[63]); Hargreaves, Fish. Brit. Guiana, 1904: 15 (Brit. Guiana).

Dasyatis scabrata Fowler, Fish Culturist, *21*, 1942: 66 (descr., size, Cuba, tail as in *D. americana* with "keel above and winglike expansion below," but "front profile of disc nearly straight"; Matanzas and Havana, Cuba).[64]

Doubtful Synonym:

Trygon hastata Bean, Bull. U. S. Fish Comm., 7, 1888: 151 (listed, Ocean City, Maryland; no clue to ident.).

Not *Raja pastinaca* Linnaeus, Syst. Nat., *1*, 1758: 232 (E. Atlant.).

Not *Pastinaca hastata* DeKay, Zool. N.Y., 4, 1842: 373, pl. 65, fig. 214; Baird, Rep. Smithson. Instn. (1854), 1855: 337 [follows p. 352]; Storer, Mem. Amer. Acad. Arts Sci., N. S. 9, 1867: 244, pl. 39, fig. 3; also, Fishes Mass., 1867: 269, pl. 39, fig. 3 (equals *Dasyatis centroura* [Mitchill] 1815; see p. 361).

Not *Trygon hastata* Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 513; Gill. Proc. Acad. nat. Sci. Philad., Addend., 1861: 62; Günther, Cat. Fish. Brit. Mus., *8*, 1870: 476 (equals *Dasyatis centroura* [Mitchill] 1815; see p. 361).

Not *Trygon* (*Himantura*) *hastatus* Duméril, Hist. Nat. Poiss., *1*, 1865: 592 (descr. after DeKay, 1842, equals *D. centroura* [Mitchill] 1815).

Not *Dasyatis hastata* Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739; Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 70 (equals *Dasyatis centroura* [Mitchill] 1815; see p. 362).

Dasyatis centroura (Mitchill) 1815

Figures 79A, 83, 84

Study Material. Eleven specimens, male and female, 400–1,415 mm wide, from Buzzards Bay and Nantucket, Massachusetts and the offing of Cape Hatteras, North

63. These American specimens seem likely to have been *americana*, because described as with margins of snout forming an obtuse angle and tail with a distinct fold below and slight ridge above.

64. Dr. Fowler has pointed out to us its probable identity with *D. americana* Hildebrand and Schroeder 1928.

Carolina, in Museum of Comparative Zoology; also a mounted female, about 1,250 mm wide, from Woods Hole, in New England Museum of Natural History; and many taken in local fish traps, examined at Woods Hole.

Distinctive Characters. Large specimens of this species are recognizable at a glance among Sting Rays of the western North Atlantic by their thorny tails, by the large size and wide spacing of their mid-dorsal bucklers, and by the conspicuous tubercles or bucklers on the outer parts of their discs. Smaller specimens, in which the large tubercles have not yet developed on the tail, differ so widely in shape of disc from *Dasyatis sabina*, *D. guttata*, and *Himantura schmardae* that there is no danger of confusing them with any of the latter. While *D. centroura* resembles *D. say* and *D. americana* more closely in shape of disc, it is easily separable from *D. say* (if undamaged) by the fact that its tail lacks any trace of a cutaneous fold above, and from *D. americana* by its much narrower ventral tailfold. Small *D. centroura* that have lost their tails might be confused with either *D. say* or *D. americana*, so closely do the three species resemble one another in general appearance prior to the full development of their dermal armature. However, the outer posterior corners of the disc are much more abruptly rounded at all ages in *centroura* than in *say* (cf. Fig. 83 with 90), and the young *centroura* remains smooth-skinned until after it has grown to a size at which *americana* has commenced to show its characteristic dorsal armature. The large size and broad spacing of the mid-dorsal bucklers on the discs of older *centroura* afford a convenient field-mark for identification, even for tailless specimens.

Description. Proportional dimensions in per cent of extreme breadth of disc. Female, 610 mm broad, and male, 1,415 mm broad, from Buzzards Bay, Massachusetts (Harv. Mus. Comp. Zool., Nos. 36508 and 36511 respectively).

Disc: vertical length 82.3, 80.0.

Snout length: in front of orbits 17.0, 15.7; in front of mouth 18.9, 16.2.

Orbits: horizontal diameter 4.9, 3.0; distance between 10.0, 9.3.

Spiracles: length 6.2, 5.4; distance between 16.2, 14.8.

Mouth: breadth 8.4, 7.0.

Exposed nostrils: distance between inner ends 10.6, 9.1.

Gill openings: lengths, 1st 3.3, 2.8; 3rd 2.9, 3.0; 5th 2.2, 1.9; distance between inner ends, 1st 18.9, 18.4; 5th 12.8, 12.6.

Pelvics: anterior margin 15.9, 14.5.

Distance: from tip of snout to center of cloaca 73.0, 68.5; from center of cloaca to origin of caudal spine 40.0, 41.0.

Disc about 1.2–1.3 times as broad as long, rhomboid; tip of snout narrowly rounded, projecting only slightly if at all; maximum anterior angle in front of spiracles about 130–140°; anterior margins nearly straight or weakly concave but altering to convex toward outer corners; posterior margins nearly straight anteriorly but becoming weakly convex posteriorly, making an angle of about 130–140° with anterior margins; posterior corners abruptly rounded or even angular; inner margins weakly convex.

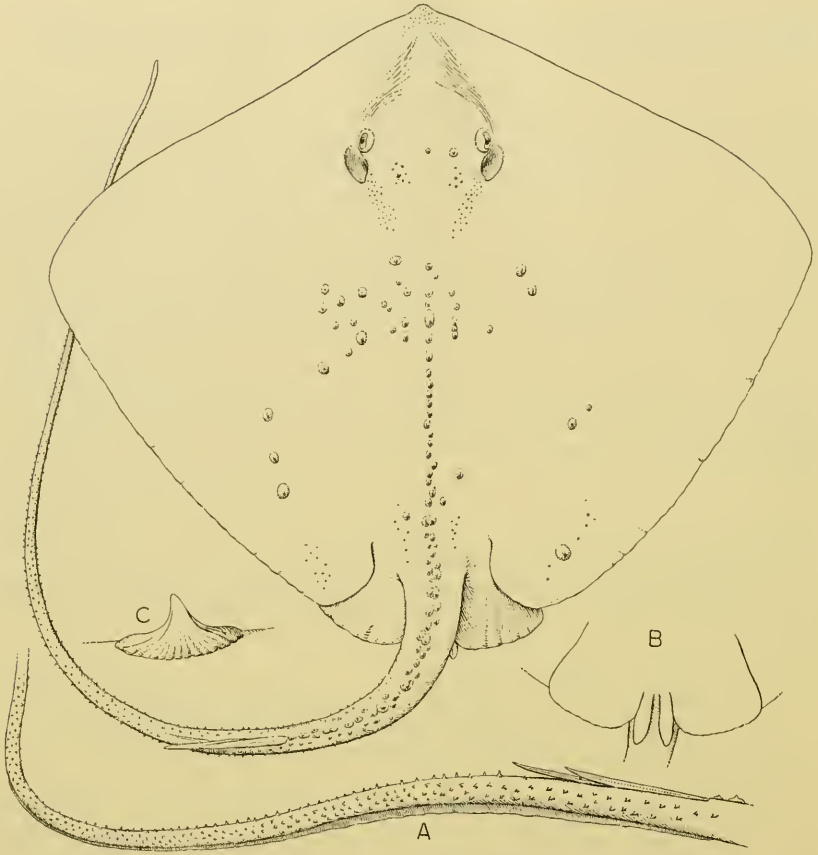


FIGURE 83. *Dasyatis centroura*, immature male, 1,415 mm wide, from Buzzards Bay, Massachusetts (Harv. Mus. Comp. Zool., No. 36511). *A* Side view of middle part of tail to slightly larger scale. *B* Ventral view of pelvic fins. *C* Tubercle from tail, about 0.8×.

Axis of greatest breadth about 47 % of distance rearward from tip of snout toward rear limit of disc. Tail from center of cloaca about 2.4–2.6 times as long as distance from center of cloaca to tip of snout; moderately depressed anterior to spine on small specimens but not appreciably so on larger; oval close posterior to spine but altering to rounded wedge-shaped in cross section (widest above) toward tip; its upper surface with a low ridge under tip of spine, rounded thence rearward; its lower surface with a well developed cutaneous fold extending rearward from below origin of spine for a

distance a little greater than that from its own origin to cloaca, then narrowing to a low ridge that merges gradually with general contour of tail; maximum breadth of lower tailfold (under middle of spine or spines) about $^1/_3$ as great as height of tail at same point.

Tail spines one, sometimes two or three, with replacement spine growing anterior to older ones on specimens studied;[65] distance from origin of first spine to center of cloaca about 47–60 % as long as distance from cloaca to snout; length of free portion of fully formed spine about half as great, its total length from origin about 70 % as great, as distance between outer margins of orbits; maximum breadth of spine about 7–8 % of its total length; about 40 teeth along distal two-thirds of spine on each side of spine of specimen counted.

Skin, apart from tail spines, wholly smooth on specimens up to 18–19 inches broad; thereafter a median series of tubercles or bucklers with blunt-tipped conical thorn developing from nuchal region to tail spine;[66] some of these bucklers large, others small, arranged either in a single row or in two or three irregular rows, depending on whether one, two or three thorns are borne on a single basal plate; bucklers on disc with longitudinally oval bases mostly imbedded in skin and without noticeable striae, but bases of those on tail oval to round and conspicuously striate; shoulder region on either side of median line of half-grown specimens and larger armed with 1–20 larger bucklers,[67] either single or with two or three springing from a single base, irregularly distributed, often with many more on one shoulder than on the other; one buckler also close in front of each eye; a few large and conspicuous single or multiple tubercles, on bases sometimes up to 25 mm in diameter, likewise finally develop on the outer posterior part of either side of the disc[68] of medium-sized specimens and larger; their discs also sparsely and irregularly strewn with prickles of various sizes. Upper surface of posterior part of tail from spine to tip, and sides of tail from about abreast the mid-point of its lower fold, rough with conspicuous thorns, decreasing in size rearward. Lower surface of disc smooth; lower surface of tail thorny rearward from about below tip of spine.

Snout in front of orbits about 0.9–1.2 times as long as distance between outer edges of orbits, its length in front of mouth about 1.6–1.8 times as great as distance between exposed nostrils and 0.9–1.0 times as great as distance between inner ends of first gill openings. Orbit about 59–67 % as long as distance between orbits and 0.9–1.0 times as long as spiracle. Distance between inner ends of first gills about 1.8–2.0 times as long as distance between exposed nostrils; distance between inner ends of fifth gills about 70–75 % as long as that between first gills. Nasal curtain reaching about to front of mouth, its free posterior margin nearly straight or weakly concave

65. As identified by their relative states of development.
66. A female specimen 35 inches wide from Buzzards Bay has a midrow of spines from nuchal region to tail, but one of the same size, a male, from Cape Hatteras, lacks these spines anterior to the axils of pectorals except for a single one at the highest part of the back.
67. Their bases sometimes up to 25 mm in diameter.
68. On a male 41 inches wide there are two of these and one small thorn on the right-hand side, three on the left, but a somewhat larger number on a female of 60 inches.

and finely fringed, the individual lobelets single or bifid with rounded tips. Mouth weakly arched on females and on immature males, its shape on fully mature males not known. Floor of mouth with a transverse row of about six fleshy papillae of different lengths.

Teeth of females and of immature males closely crowded in quincunx; tetragonal with rounded corners, the functional surface more or less flattened, without cusp and

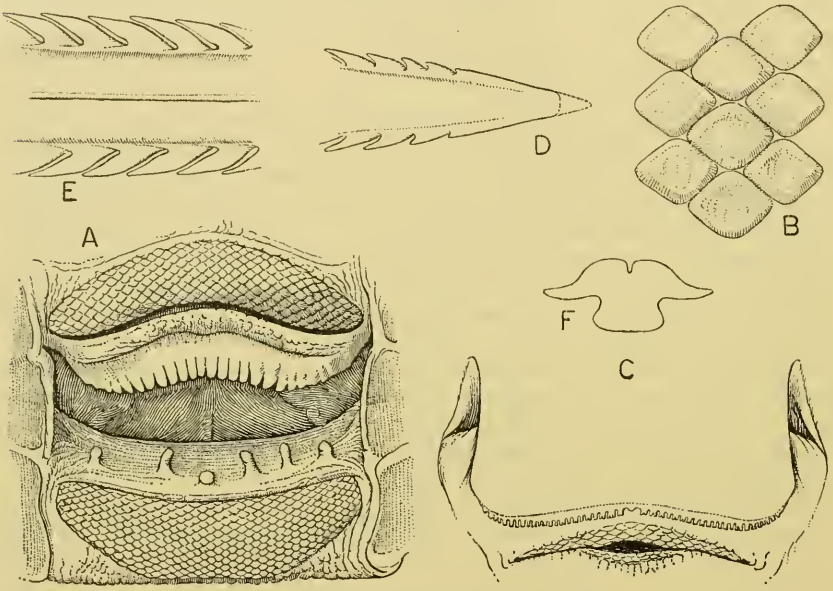


FIGURE 84. *Dasyatis centroura*. *A* Opened mouth of female, about 1,330 mm wide, from Woods Hole, Massachusetts (Harv. Mus. Comp. Zool., No. 36513) to show tooth bands, transverse curtain on roof of mouth, and papillae on floor of mouth, about 0.6×. *B* Upper teeth of same from near middle of jaw, about 5.2×. *C* Nostrils and mouth of male pictured in Fig. 83, about 1.2×. *D* Tip of tail spine. *E* Middle part of spine. *F* Cross section of middle part of spine of same, about 5.8×.

variously grooved with wear; about seven rows in function simultaneously in center of upper jaw, about 12–14 rows in center of lower jaw, progressively fewer rows in function toward corners. Teeth of mature males not seen.

Pelvics quadrate; anterior and distal margins nearly straight or only weakly convex, the inner margins a little more strongly so; outer corners abruptly rounded, posterior corners more broadly so; anterior margin about 75–80 % as long as distance from its own origin to rear tip of longest ray of pelvic.

Color. Described as olive-brown above, white or nearly so below. Fresh-caught

specimens, seen by us at Woods Hole, have been dark brownish above, the tail black from spine rearward, the lower surface white and without dark edgings.

Relationship to Extralimital Species. Some authors[69] have considered *D. centroura* of the western Atlantic identical with *D. aspera* (Cuvier) 1817[70] of the Mediterranean, Madeira, and tropical West Africa,[71] and the two forms do resemble one another closely in general form of disc, in dermal armature (especially thorniness of the tails of adults) and in the narrowness of the lower tailfold combined with the absence of an upper tailfold. However, final decision as to their exact relationship will require comparison of adult specimens from the two sides of the ocean. Awaiting this, it seems best to recognize both species of the pair, especially since the two appear to be characteristic of rather different thermal zones, *D. aspera* of the tropical-subtropical regions, *D. centroura* of warm-temperate regions.

Size. Apparently *D. centroura* does not become sexually mature until it attains a breadth of four feet or more, for the claspers extend only a little beyond the tips of the pelvic fins in a male of about 41 inches, and they were not much more developed in one of 56 inches that we have examined. Thus it appears that the great majority of specimens that have been studied, i. e., up to 40–56 inches wide, have been immature.[72] When fully grown this appears to be the largest of the Sting Rays of the western North Atlantic. The maximum width definitely recorded for a specimen certainly of this species, is five feet.[73] The greatest measured length, so far as we can learn, is 10 feet 3 inches.[74] But it is certain that some reach a considerably larger size, for a New Jersey specimen has been described as nearly seven feet across,[75] which, if its tail were nearly complete, would have been 13–14 feet long. Thus it rivals in size the giant Sting Ray of Australia and New Zealand (*Dasyatis brevicaudata* [Hutton] 1875), which has been characterized as "the largest stingaree in the world."[76]

The size at birth is not known. The smallest specimens that can be referred with full confidence to *D. centroura* are one about 17½ inches broad, reported many years ago,[77] and another 15¾ inches broad, taken at Woods Hole during the summer of 1946 (see Study Material, p. 352).

Specimens taken at Woods Hole weighed about 16–22 pounds at a breadth of 24–26 inches; 26–40 pounds at 30–32 inches; 45–55 pounds at 34–36 inches; 65–75

69. Notably Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 382.

70. See Rey (Fauna Iberica, Peces, *1*, 1928: 626) for a good account and illustration of a young specimen of *D. aspera*; Doderlein (Man. Ittiol. Medit., 2, 1881: 228, as *Trygon thalassia*) for an early history of the species and an extensive list of references, including pre-Linnean ones; Vinciguerra (Ann. Mus. Stor. nat. Genova, *51*, 1923: 76) for discussion of the validity of *D. thalassia* (Müller and Henle) 1841, leading to the conclusion that it is not a distinct species.

71. For list of West African localities and references, see Fowler (Bull. Amer. Mus. nat. Hist., 70 [1], 1936: 126).

72. Gravid females only two feet wide, reported from New Jersey under the specific name *D. centrourus* by Moore (Bull. U. S. Fish Comm., *12*, 1894: 358), almost certainly belonged to some other species of Sting Ray.

73. Fowler, Rep. N. J. Mus. (1905), 1906: 76.

74. For one specimen, the breadth of which was not recorded (Garman, Bull. U. S. nat. Mus., *16*, 1883: 67), and for another only 42 inches broad, the tip of whose tail was missing, caught in Sandy Hook Bay near New York in 1927 (Breder, Copeia, 166, 1928: 6).

75. Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1929: 608.

76. Whitley, Fish. Aust., *1*, 1940: 202, fig. 227.

77. Garman, Bull. U. S. nat. Mus., *16*, 1883: 67.

pounds at 38–40 inches; 130–150 pounds at 46–50 inches; and 155 pounds at 52 inches.[78] Another 52 inches broad weighed 180 pounds,[79] and a weight of 350 pounds, reported for one seven feet wide, may not have been exaggerated. Different individuals of a given size may vary by nearly 100 % in weight in extreme cases. The relationship between size and weight is about the same for the one sex as for the other before they become sexually mature; but it is likely that gravid females may be heavier than males of equal size.

Developmental Stages. Embryos of this Ray have not been studied as yet, nor is the number in a brood known.[80]

Habits. Nothing is known of the way of life of *D. centroura* to differentiate it from other Sting Rays. Probably it subsists chiefly on whatever large crustaceans and hard-shelled mollusks are most readily available locally. The stomachs of specimens taken near Woods Hole have contained large numbers of crabs (*Cancer*), clams (*Mya*), and large gastropods (*Lunatia*, equals *Polinices*), as well as squid (*Loligo*) and annelid worms; one contained fragments of a small fish. It bites readily on bait of crabs, clams, or fish.

Its breeding habits are yet to be learned, as is the season at which it produces its young.[81]

D. centroura is known only as a warm-season visitor to coastal waters. In the vicinity of New York it appears in June, earlier or later in different years.[82] Thereafter it is encountered in New Jersey, New York and Rhode Island waters through July, August, and September,[83] occasionally in the first week of October. Apparently it appears equally early in the season as far east as southern Massachusetts, having been reported repeatedly in the vicinity of Woods Hole in June. But available information suggests that its autumnal withdrawal thence takes place several weeks earlier in the season than from the shores of New York and New Jersey, for the latest capture so far reported at Woods Hole is August 25. It freely enters the inlets and larger bays and sounds, such as Long Island Sound, Narragansett Bay, Vineyard Sound, and Buzzards Bay, and it has been reported repeatedly in more nearly estuarine situations, such as Sandy Hook Bay and Great Egg Harbor on the coast of New Jersey. It has never been reported from brackish or fresh waters. Although it is sometimes seined in the surf, it seems to remain more commonly in water as deep as that fished by the pound nets (30 ft. or so at high tide), for we find no report of a bather wounded by one. On

78. Based on 28 specimens weighed at Woods Hole during the summer of 1946.
79. Breder, Copeia, 166, 1928: 6.
80. Broods of four and five have been reported by Moore (Bull. U. S. Fish Comm., *12*, 1894: 358) as born in an aquarium, but it seems almost certain that they were of some other species, for the mothers were described as only two feet wide, a size much smaller than that at which *D. centroura* matures.
81. An earlier statement (Moore, Bull. U. S. Fish Comm., *12*, 1894: 358) that adult *D. centroura* desert the bays of New Jersey after bringing forth their young and that all taken there after August 20 were young of the year seems to have referred to some other and smaller Ray, for the breadth of females that produced young in the aquarium was given as only two feet.
82. The earliest recorded date with which we are acquainted is June 3 for Orient at the eastern end of Long Island, New York.
83. Daniel Merriman and Yngve H. Olsen advise us that an immature female, 58 inches long to end of tail, weighing 24½ pounds, was trawled September 25, 1950, 5 miles SSE of Watch Hill, Rhode Island.

the other hand, it has been reported as deep as 6–20 fathoms; and some may summer where the depth is as great as 20–30 fathoms, if reports of their occurrence on Georges Bank are well founded.

Little is known of its movements between the dates of its autumnal disappearance from the bays and inshore waters and of its reappearance in early summer. There is no evidence of autumnal incursions by it along the coasts of Maryland, Virginia, or North Carolina; the fact that one was trawled off Cape Hatteras in February[84] suggests that it simply withdraws offshore into somewhat deeper waters at the onset of autumnal cooling to spend a quiescent winter on the bottom.

Numerical Abundance. Sometimes as many as 8–10 are taken in one lift of a pound net during July and August in Vineyard Sound and Buzzards Bay near Woods Hole; 12–15 have often been on display simultaneously in the large aquarium of the U. S. Fish and Wildlife Service Station at Woods Hole. We estimate that the total catch during ordinary summers by the pound nets (9–12) that operate in that vicinity is at least 400–500 specimens, and reports indicate a catch of the same order of magnitude along the outer coast of Rhode Island. However, the stock appears to vary widely in abundance from year to year and over periods of years. Although information is not sufficient to outline these fluctuations in detail, there seems to have been a period of abundance from eastern New England to New Jersey during the middle third of the 19th century, followed by a period of scarcity during the last part of the century. In New Jersey waters an upswing appears to have occurred during the few years following 1900, when 39 were taken in one seine haul near Cape May.[85] But a decrease was recorded in 1907 following a cold spring.[86] And *D. centroura* was so uncommon in the immediate vicinity of New York in 1921 that the capture of two specimens seemed worth reporting.[87] But by 1928 it was so plentiful again along the mid-New Jersey coast that large ones were hooked every day in the vicinity of Barnegat through late summer until mid-September.[88]

Relationship to Man. No regular commercial use is made of *D. centroura* at present along the Atlantic Coast of the United States, although some caught on the New Jersey Coast were used earlier as fertilizer. Being so large, with tail spines sometimes as much as five inches long, they are extremely dangerous to handle. The wounds they can inflict have been greatly dreaded for a century or more, and therefore it has been common practice to chop off their tails at once when caught and thus render them harmless.

Range. Coastal waters of the western North Atlantic from Georges Bank and Cape Cod to Chesapeake Bay, to Cape Hatteras, possibly to Florida. It is represented in Uruguayan waters by a form so closely allied that no clear-cut differences from the northern *D. centroura* appear in the published accounts and illustrations of it.[89]

84. This specimen, 35 inches wide, was taken by the U. S. Fish and Wildlife Service vessel ALBATROSS III in Lat. 34°38′ N, Long. 75°58′ W, in 20 fathoms, February 19, 1950 (Harv. Mus. Comp. Zool., No. 37058).
85. Fowler, Rep. N. J. Mus. (1905), 1906: 76.
86. Fowler, Rep. N. J. Mus. (1907), 1908: 131.
87. Townsend and Nichols, Copeia, 91, 1921: 10.
88. Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1929: 608.
89. Devincenzi, Rev. chil. Hist. nat., *29*, 1925: 173, 174, pl. 4, fig. 1–1″; An. Mus. Hist. nat. Montevideo, (2) *2*, 1926: 204; Devincenzi and Barattini, An. Mus. Hist. nat. Montevideo, Suppl. Album Ictiol., 1926: pl. 5, fig. 4; Reiter, Sports Afield, (6) *122*, 1949: 23.

As pointed out on p. 357, *D. centroura* of the western Atlantic is so close to *D. aspera* (Cuvier) 1817 of the Mediterranean, Madeira, and tropical West Africa, that it is an open question whether or not the two are separable.

Details of Occurrence. Until recently the coast sector from Delaware Bay to Nantucket and Cape Cod, Massachusetts, was the only region north of the equator whence reports of the presence of this great Ray were supported by conclusive evidence. Within this sector, however, it is to be expected anywhere in suitable situations. Thus it has been reliably recorded from: Delaware Bay (Green Creek); numerous localities scattered along the New Jersey Coast, from Cape May to Sandy Hook Bay, both along the open beaches and within inlets and bays;[90] New York Harbor; Orient at the eastern end of Long Island; Stratford, Connecticut; Narragansett Bay and along the Rhode Island Coast; near Block Island; and the vicinity of Woods Hole. This last locality appears to mark the boundary of its regular occurrence northeastward, for the only definite records of its presence farther east or north are of one specimen from Nantucket Island (see Study Material) and another reported from Chatham on the outer coast of Cape Cod, many years ago. Also it is said to have been seen on the shoaler parts of Georges Bank.[91]

To the southward *D. centroura* is reported from the inner parts of Chesapeake Bay and off the mouth of the latter, but without evidence of actual identity.[92] The most southerly positive record for it is of a specimen taken recently off Cape Hatteras, North Carolina.[93] And it is hardly conceivable that the presence of so large and so formidable a Ray would not have been reported frequently along the South Atlantic[94] and Gulf coasts of the United States if it occurred there in numbers at all approaching those that visit the coasts of New Jersey, New York, and southern New England. Nor has it been reported from the West Indian region, from the Caribbean, from the coasts of the Guianas, or from Brazil.

This seeming absence of *D. centroura* from the whole tropical-subtropical belt of the western Atlantic in both hemispheres lends special interest to the fact that a similar Ray has been taken recently at Los Pocitos Beach, Mercedes, Uruguay, near the mouth of the Rio Uruguay. According to the published description and illustration, it resembles the northern *D. centroura* so closely, especially in form of disc, in dermal armature, and in tailfold, that it was recorded as that species (see *Range*). The latitudinal range of *D. centroura*, with its southern hemisphere counterpart, thus parallels that of the *Raja radiata* and *R. doello-juradoi* pair and of the *R. spinicauda* and *griseocaudata* pair among Skates (pp. 255, 275), and of several pairs of Shark species.

90. New Jersey localities of definite record, south to north, are: Green Creek (on Delaware Bay); Cape May; Sea Island City; off Palermo; Corson Inlet; Somers Point; Beesely Point; Ocean City; Ventnor; Atlantic City; Great Egg Harbor; Beach Haven; Barnegat Inlet; Bradley Beach; Ocean Grove; Long Branch; and Port Monmouth in Sandy Hook Bay.

91. Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 70. It has sometimes been said that its range extends northward to Maine (so stated by Jordan and Evermann [Bull. U. S. nat. Mus., 47 (1), 1896: 83], and by some subsequent authors, doubtless upon Jordan and Evermann's authority), but seemingly there is no factual warrant for this.

92. Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 187; 2nd ed., 1876: 158.

93. See Study Material, p. 352; also p. 359, footnote 84.

94. Early reports of it from South Carolina and from Florida were by name only.

Synonyms and References:[95]

Raja centroura Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 479 (descr., size, Long Island, New York).

Trygon, no specific name, Storer, Rep. Fish. Rept. Birds Mass., 1839: 200 (nos., south. Mass., ident. probable from local.).

Pastinaca hastata DeKay, Zool. N.Y., 4, 1842: 473, pl. 65, fig. 214 (descr., ill., Rhode Island); Ayres, Boston J. nat. Hist., *4*, 1843: 289 (nos., size, no. tail spines, season, Long Island, New York); Storer, Mem. Amer. Acad. Arts Sci., (2) *9*, 1867: 244, pl. 39, fig. 3; also, Fishes Mass., 1867: 269, pl. 39, fig. 3 (descr., size, season, nos., ill., C. Cod and south. Mass.); Baird, Fishes N. Jersey, Rep. Smithson. Instn. (1854), 1855: 337 (follows p. 352) (nos., danger to fishermen, New Jersey).

Pastinaca centroura DeKay, Zool. N.Y., 4, 1842; 373, note (doubts if it equals *P. hastata* DeKay).

Trigon centroura Linsley, Amer. J. Sci., *47*, 1844: 78 (size, tail spines, nos., Conn.).

Trygon hastata Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 513 (diagn., Rhode Island, Conn.); Proc. Boston Soc. nat. Hist., *2*, 1848: 170 (Marthas Vineyard); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed Atlant. Coast N. Amer.); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 476 (descr. by ref. to DeKay, 1842; New York).

Trygon centrura[96] Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole); Verrill and Smith, Rep. U. S. Comm. Fish. (1871–1872), 1873: 521 (food, season, Woods Hole); Smith, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (copepod parasites, Vineyard Sound); Rathbun, Proc. U. S. nat. Mus., *7*, 1885: 487 (copepod parasites, Vineyard Sound); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, N. Atlant., U. S.); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Norman and Fraser, Giant Fishes, 1937: 72, fig. 29A (ill., Atlant. Coast N. Amer.).

Dasybatis centrurus[97] Bean, Proc. U. S. nat. Mus., *3*, 1880: 114 (listed, no local.); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 3, 4, 8, 9, 10, 11, 23, 25, 29, 30, 43, 64, 77, 83, 84, 89, 98 (cestode parasites, Woods Hole); Breder, Copeia, 166, 1928: 6 (size, weight, season, near New York).

Dasyatis centrurus[98] Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 47 (diagn., color, size, C. Cod to Florida, but may include other species as well); Smith, Bull. U. S. Fish. Comm., *12*, 1894: 368 (size, nos., danger to fishermen, season, New Jersey); Bean, Bull. Amer. Mus. nat. Hist., *9*, 1897: 331 (season, nos., Gravesend Bay); Linton, Proc. U. S. nat. Mus., *20*, 1897: 424, 439, 440, 442, 443, 444, 446, 448, 452 (cestode parasites, Woods Hole); Smith, Bull. U. S. Fish Comm., *17*, 1898: 90 (nos., season, danger to fishermen, Woods Hole); Linton, Bull. U. S. Fish Comm., *19*, 1901: 275 (cestode parasites, Woods Hole), 432 (stom. contents, nematode parasites, Woods Hole); Bean, Bull. N.Y. St. Mus., 60, Zool. *9*, 1903: 53 (descr., nos., danger to fishermen, near New York); Wilson, Proc. U. S. nat. Mus., *28*, 1905: 573, 621 (copepod parasites, Vineyard Sound); Tracy, Rep. R. I. Comm. inl. Fish., 1906: 48 (nos., season, Rhode Island); Smith, N. C. geol. econ. Surv., *2*, 1907: 44 (descr., diet, but no N. Carolina record); Sullivan, Bull. U. S. Bur. Fish., *27*, 1907: 13, 21 (physiol.); Fowler, Rep. N. J. Mus. (1907), 1908: 131 (size, nos., New Jersey); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 14 (New England locals.); Fowler, Rep. N. J. Mus. (1908), 1910: 353 (New Jersey); Proc. Acad. nat. Sci. Philad., *62*, 1910: 473 (young reported, no local.); Tracy, Rep. R. I. Comm. inl. Fish., 1910: 63 (size, Rhode Island); Halkett, Check List Fish. Canad., 1913: 43 (listed, Hatteras to Maine); Nichols, Abstr. Linn. Soc. N. Y., 20–23, 1913: 92 (listed, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739 (nos., season, food, parasites, Woods Hole); Fowler, Copeia, 31, 1916: 41 (depth, New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 146 (New Jersey); Townsend, 25th Annu. Rep. N.Y. Zool. Soc. (1920), 1921: 126 (listed New York Bay); Townsend and Nichols, Copeia, 91, 1921: 10 (season, New York); Latham, Copeia, 99, 1921: 72 (nos., season, Long Island, New York); Fowler, Copeia, 156, 1926: 146 (size, New Jersey); Nichols and Breder, Zoologica N.Y., *9*, 1927: 26 (season, nos., food, New York and south. New England); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 64 (descr., Chesapeake Bay by ref. to Uhler and Lugger, 1876); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 34 (genl.); Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1929: 608 (size, weight, nos., season, New Jersey); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn.);

95. For synonyms and references for *D. aspera* (Cuvier) 1817 of the eastern Atlantic, see especially Doderlein (Man. Ittiol. Medit., 2, 1881: 228, as *Trygon thalassia*), Rey (Fauna Iberica, Peces, *1*, 1928: 626), and Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 126, as *Dasyatis centroura*).

96. Sometimes spelled *centroura*, *centrourus*, or *centrurus*.

97. Sometimes spelled *centrura*.

98. Also spelled *centrourus* and *centroura*.

Truitt, Bean and Fowler, Bull. Md. Conserv. Dept., 3, 1929: 31 (descr., Chesapeake Bay)[99]; Breder, Copeia, 1932: 31–32 (nos., season, Block Island); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 126 (descr., New Jersey); Breder, Bull. N.Y. zool. Soc., *41*, 1938: 28 (listed, New York Harbor); Gudger, Sci. Mon. N.Y., [*63*], Aug. 1946: 113 (ill.).

Dasibatis centrura Garman, Bull. U. S. nat. Mus., 16, 1883: 67 (descr., color, cf. European *D. pastinaca*, size, range).

Dasyatis (*Hemitrygon*) *centrura* Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 83 (descr., size, Maine to C. Hatteras); Rep. U. S. Comm. Fish. (1895), 1896: 223 (listed, Maine to C. Hatteras).

Dasybatus centroura Fowler, Rep. N. J. Mus. (1905), 1906: 76 (diagn., nos., size, New Jersey); Rep. N. J. Mus. (1906), 1907: 261 (size, capture, New Jersey); Bigelow and Schroeder, Canad. Atlant. Fauna, 12e, 1934: 37 (descr., ill., C. Cod and Georges Bank to C. Hatteras).

Dasyatis hastata Tracy, Rep. R. I. Comm. inl. Fish., 1906: 48 (Rhode Island by ref. to DeKay, 1842); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 14 (New England locals.); Tracy, Rep. R. I. Comm. inl. Fish., 1910: 63 (Rhode Island and Mass., by ref. to DeKay, 1842).

Dasyatis hastata Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739 (Woods Hole, by ref. to Storer, 1867).

Dasybatus (*Pastinachus*) *marinus*[100] Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 382, pl. 33, figs. 1, 2, 4; pl. 44, fig. 7; pl. 53, fig. 5 (descr., ills., but not European refs.).

Dasybatus marinus Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 273 (in Key); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 70 (descr., ill., size, C. Cod, south. Mass., Georges Bank); Wilson, Bull. U. S. nat. Mus., *158*, 1932: 457, 472, 521 (copepod parasites, Woods Hole); Merriman and Warfel, Bull. Bingham oceanogr. Coll., *11* (4), 1948: 135 (listed, off Rhode Island, Connecticut).

Dasybatus hastatus Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 70 (C. Cod, by ref. to Storer, 1867).

Pastinachus centrourus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (listed, Maine to C. Hatteras); Sproston, Trans. zool. Soc. Lond., *25* (4), 1946: 533 (trematode parasites, Woods Hole, Mass., but ref. for Labrador doubtless erroneous).

Doubtful Synonyms and References:

Trygon centrura Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 187; 2nd ed., 1876: 158 (listed, entrance to Chesapeake Bay).

Dasyatis centrurus True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 260 (listed, S. Carolina); Moore, Bull. U. S. Fish Comm., *12*, 1894: 358 (probably not this species because female, only two feet wide, with young; New Jersey); Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210 (listed, Florida, ident. doubtful because of local.); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (listed, Florida, by ref. to Henshall, 1895); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 161, 264 (listed, S. Carolina, Florida).

Dasibatis marina Devincenzi, Rev. chil. Hist. nat., *29*, 1925: 174, pl. 4, fig. 1–1″ (ill., Uruguay).

Dasybatis marina Devincenzi, An. Mus. Hist. nat. Montevideo, (2) *2*, 1926: 204 (descr., meas. of same specimen as in Devincenzi, 1925, Rio de la Plata, near mouth of R. Uruguay); Devincenzi and Barattini, An. Mus. Hist. nat. Montevideo, Suppl. Album Ictiol., 1926: pl. 5, fig. 4 (ill., Uruguay); Pozzi and Bordale, An. Soc. cient. argent., 120, 1935: 154 (listed, Argentina, Lat. 35° S).[101]

Not *Trygon centrura* Yarrow, Proc. Acad. nat. Sci. Philad., [29], 1877: 216 (N. Carolina; probably *Dasyatis say*, because of local. and nos., see p. 387).

Not *Dasyatis centroura* Fowler, Proc. Acad. nat. Sci. Philad., *61*, 1909: 407 (Delaware Bay, later refd. by Fowler [Proc. Acad. nat. Sci. Philad., *62*, 1910: 473] to *Dasyatis say*, but subsequently by Fowler [Proc. biol. Soc. Wash., *33*, 1920: 146] to *Dasyatis hastatus*, which is equivalent to *Dasyatis americana*); Delsman, Mém. Mus. Hist. nat. Belg., (2) *3* Fasc. 21, 1941: 49 (listed, tropical W. Afr., ident. doubtful).

99. Probably by ref. to Uhler and Lugger, 1876.

100. The earliest post-Linnean use of the species name *marinus* for a Sting Ray appears to have been by Klein in the anonymous Neuer Schauplatz, *1*, 1775: 992. But Klein's names have been declared invalid by the International Commission on Zoological Nomenclature (Opin. 89, Smithson. misc. Coll., *73* [5], 1925: 28); hence *marinus*, as used in the present connection, must date from Garman, 1913, who revived it to include both the American *D. centroura* and the European *D. aspera* (Cuvier) 1817, to which *D. thalassia* (Müller and Henle) 1841 is no doubt equivalent.

101. See discussion, p. 360.

Dasyatis geijskesi Boeseman 1948

Figure 85

Study Material. None.

Distinctive Characters. This newly described species[102] differs noticeably from all other known dasyatid Rays of the Atlantic in shape of disc with narrowly projecting snout, and pelvic fins with long anterior margins and narrowly pointed and somewhat falcate outer corners.

Description.[103] Proportional dimensions in per cent of extreme breadth.

Disc: length 103.0.

Snout length: in front of orbits 42.7; in front of mouth 41.2.

Orbits: horizontal diameter 1.8; distance between 10.0.

Spiracles: length 5.2; distance between 14.7.

Mouth: breadth 8.5.

Exposed nostrils: distance between inner ends 11.8.

Gill openings: longest 2.8; distance between inner ends, 1st 14.7; 5th 13.0.

Pelvics: anterior margin 35.3.

Distance: from tip of snout to center of cloaca 92.5.

Disc about as broad as long; anterior margins deeply concave, the snout projecting conspicuously as shown in Fig. 85, slightly blunted at tip; outer corners broadly rounded, outer posterior margins moderately and evenly convex, but posterior corners well rounded; inner margins weakly convex and somewhat excavate at axils. Axis of greatest breadth about 48 % of distance back from tip of snout toward level of axils of pectorals. Tail slender, whip-like, somewhat flattened dorsoventrally in advance of tail spines but more rounded posteriorly, with a low keel on either side; upper surface of tail with a low keel originating a little behind tip of second spine, gradually disappearing rearward; lower surface of tail (on juvenile male) with a shallow median groove along anterior part and a narrow cutaneous fold extending rearward for a distance about $^1/_5$ (22 %) as great as length of disc from a little anterior to insertion of spine, its maximum width about $^1/_3$ as great as longitudinal diameter of eye; dorsal keel and ventral fold perhaps becoming larger with growth; length of tail (somewhat mutilated) from center of cloaca about 2.35 times as great as distance from center of cloaca to tip of snout and almost 2.1 times as great as length of disc.

Two tail spines (on only specimen known) sharp-tipped and laterally serrate, the anterior spine about twice as long as eye, the posterior spine about 4.5 times the eye; the longer spine about 8 % as wide as long.

Central belt on upper surface of disc and on upper surface of tail posterior to spines rough with small low tubercles, rounded on disc but more conical and with radiate bases on tail; a median row of larger tubercles from nuchal region to a little anterior to tail spines, interrupted on posterior part of disc, the tubercles widely spaced on tail; median tubercles with narrow flat-topped crest rising from front to rear, more

102. Known only from the original account (see Reference, p. 364). 103. After Boeseman.

or less spine-like posteriorly, the bases pear-shaped; two similar tubercles on each shoulder; upper surface smooth elsewhere. Lower surface smooth.

Snout in front of eyes about 4.3 times as long as distance between orbits; its length in front of mouth about 3.5 times as great as distance between exposed nostrils. Eye small, a little less than $^1/_5$ (18%) as long as distance between orbits. Spiracle about three times as long as eye. Posterior margin of nasal curtain finely fringed. Lower jaw a little indented at symphysis and upper jaw projecting a little to correspond. Floor

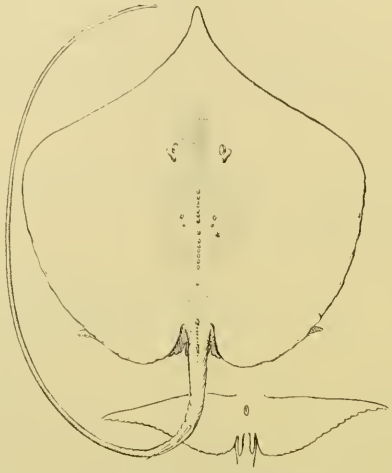


FIGURE 85. *Dasyatis geijskesi*, juvenile male, about 340 mm wide; after Boeseman.

of mouth with one median papilla flanked on either side by several low and indistinct prominences, perhaps forerunners of future papillae.

Teeth about $\frac{68}{58}$, oval or rhomboid, in quincunx.

Pelvic fins of distinctive shape; anterior margins straight, about 2.2 times as long as distance from origin of pelvic to its rear limit; outer corners slenderly pointed; posterior margin concave outwardly but becoming convex inwardly to merge with broadly rounded rear corner, the curvature continuing around short inner margin; posterior limits of pelvics a little anterior to posterior limits of pectorals.

Color. Upper surface described as dark brown, lower surface as pale with darker margins and teeth as yellowish white.

Size. The only specimen seen, with disc 360 mm long, was a juvenile male. The size at maturity is not known.

Range. Known only from the type specimen taken at Surinam (Dutch Guiana).

Reference:

Dasyatis geijskesi Boeseman, Zoöl. Meded., 30 (2), 1948: 38 (descr., ills., Surinam [Dutch Guiana]).

Dasyatis guttata (Bloch and Schneider) 1801

Figures 86, 87

Study Material. Eighteen specimens, 210 to 710 mm broad; nine embryos, 108 to 133 mm broad, eight with small yolk sac still attached and one with umbilical scar only; all from Rio de Janeiro and vicinity, Para, and Marajo Island at the mouth of the Amazon River, in the collection of the Harvard Museum of Comparative Zoology.

Distinctive Characters. Thanks to its projecting snout, *D. guttata* differs widely in appearance from all other long-tailed Sting Rays of the western Atlantic except *D. sabina* and *D. geijskesi.* The much more abruptly rounded outer corners of the disc set *D. guttata* of all sizes apart from *D. sabina*, the shape of disc and pelvics from *D. geijskesi* (cf. Fig. 86 with 85). The blunt and close-set tubercles that clothe the midzone of its disc are also diagnostic for *D. guttata*, except for young specimens.

Description. Proportional dimensions in per cent of extreme breadth of disc. Male, 455 mm broad, from Para, and female, 710 mm broad, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., Nos. 573 and 993 respectively).

Disc: vertical length 90.0, 93.0.

Snout length: in front of orbits 22.6, 25.1; in front of mouth 24.9, 26.3.

Orbits: horizontal diameter 5.5, 4.9; distance between 11.4, 13.0.

Spiracles: length 5.9, 6.2; distance between 14.1, 16.2.

Mouth: breadth 7.5, 8.7.

Exposed nostrils: distance between inner ends 9.0, 9.4.

Gill openings: lengths, 1st 2.9, 2.5; 3rd 2.9, 2.8; 5th 1.8, 2.0; distance between inner ends, 1st 15.9, 20.0; 5th 11.0, 12.5.

Pelvics: anterior margin 15.8, 18.2.

Distance: from tip of snout to center of cloaca 78.7, 84.3; from center of cloaca to origin of caudal spine 43.0, 43.1.

Disc rhomboid, about 1.1 times as broad as long, both in small specimens and in larger; snout with blunted tip, projecting conspicuously from the general contour in subtriangular form; maximum anterior angle in front of spiracles about 105–115°; outer anterior margins of disc slightly convex toward outer corners but weakly concave anterior to level of eyes; outer corners abruptly rounded to subangular, forming approximately a right angle; posterior corners more broadly rounded; posterior margins weakly convex, increasingly so toward posterior corners; inner margins moderately convex. Axis of greatest breadth about 50 % of distance rearward from tip of snout toward posterior limit of disc. Tail from center of cloaca about 2.5 times as long as distance from center of cloaca to tip of snout,[104] moderately compressed laterally, oval in cross section anterior to spine, approximately round from spine back to tip; its sides without ridges, but lower surface with a well developed cutaneous fold originating about under origin of spine and extending rearward for a distance about 1.25 times as long as distance from origin of spine to cloaca; its width about $^2/_3$–$^4/_5$ as great as height

104. Often damaged.

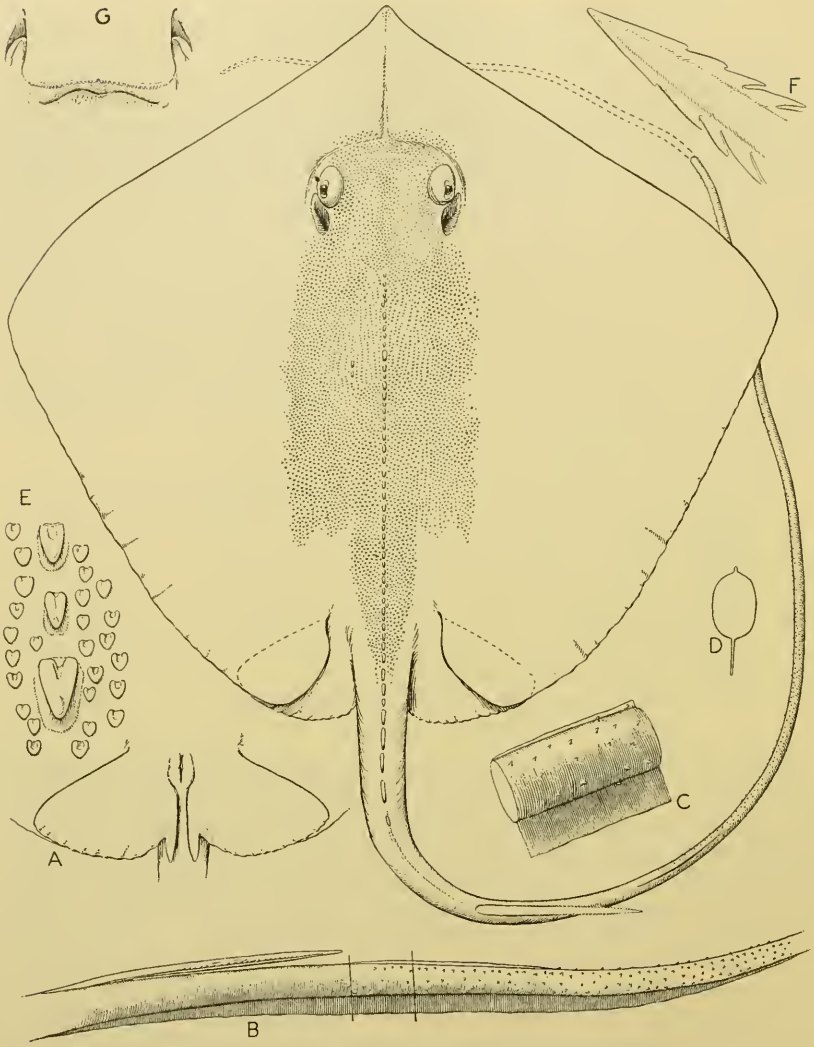


FIGURE 86. *Dasyatis guttata*, immature male, 455 mm wide, from Para, Brazil (Harv. Mus. Comp. Zool., No. 573). *A* Ventral view of pelvic fins of same. *B* Side view of middle part of tail of same, about 0.7×. *C* Side view of tail, between vertical lines marked on *B*, to larger scale. *D* Cross section of tail a little rearward from tip of tail spine. *E* Large tubercles and small, from midline of disc a little rearward from shoulder region, about 3.2×. *F* Side view of tip of tail spine, about 7.3×. *G* Nostrils and mouth of female, 286 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 322).

of tail along median third of its length, tapering toward its posterior end to merge gradually with lower surface of tail. Upper surface of tail with a low cutaneous ridge originating about under tip of tail spine and extending rearward about three-quarters as far as lower tailfold.

Tail spine (only one on specimens examined) about 1.2 times as long from its origin as distance between outer margins of orbits, its free portion about 80 % as long;

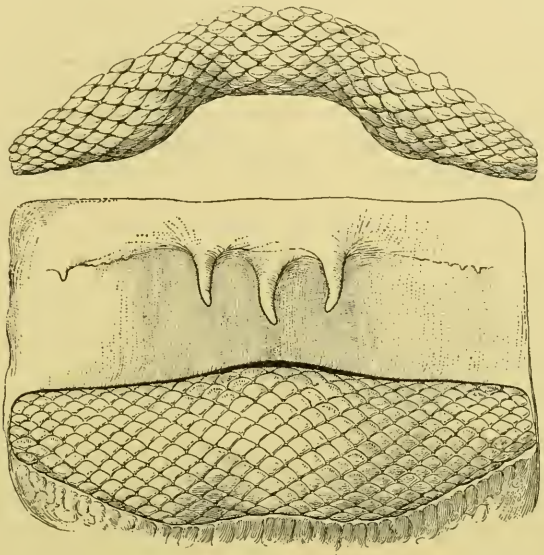


FIGURE 87. *Dasyatis guttata*, upper tooth band (above) and lower tooth band with oral papillae (below) of immature male pictured in Fig. 86, about 1.3×.

its breadth about 7 % as great as its total length; 26 lateral teeth on each side on specimen counted (255 mm wide), the outer cutting edges obtusely angular.

Skin, apart from tail spine, smooth on embryos and probably on newborn specimens; but 3–4 tubercles developing soon after birth over pectoral girdle and 2–3 on anterior part of tail, the series soon becoming continuous from nuchal region back to a little in advance of tail spine; the tubercles largest over pectoral girdle and on base of tail; those over pectoral girdle heart-shaped in dorsal aspect, those rearward with narrow median crest sloping anteriorly but vertically truncate posteriorly; each shoulder with two large tubercles on some small specimens but not on larger individuals. Smaller, blunt, heart-shaped tubercles appear also along the midbelt of the disc from the time the breadth has reached 300 mm, developing sparsely between the orbits but closely

thence rearward over a zone of considerable breadth to a little in advance of the pelvic girdle, where the zone thus roughened narrows abruptly onto the base of the tail. Tail posterior to spine rather sparsely strewn with smaller sharper thorns or large prickles from upper side down to lower side. Lower surface of disc and of anterior part of tail smooth at all stages of growth.

Snout in front of eyes about 1.4 times as long as distance between outer margins of orbits, its length in front of mouth about 2.7–2.9 times as great as distance between exposed nostrils and 1.4–1.5 times as great as distance between inner ends of first gill openings. Distance between inner ends of first gill openings about 1.8–2.1 times as long as distance between exposed nostrils; distance between inner ends of fifth gills 60–70 % as long as that between first gills. Posterior margin of nasal curtain nearly straight or weakly concave, fringed with short lobes, simple or bifid and rounded at tip. Upper jaw strongly arched forward but projecting a little rearward centrally, the lower jaw weakly recessed to correspond. Floor of mouth centrally with three stout papillae in transverse series.

Teeth $\frac{34-46}{34-46}$; those of females and immature males tetragonal with rounded corners, the functioning surface weakly arched or flat and often ridged by wear, the uppers largest about midway between center of jaw and outer corners, the lowers about uniform in size all along jaw except near outer corners where somewhat smaller; 6–7 rows in function simultaneously in upper jaw, 8–9 rows along central part of lower jaw, 6–8 rows toward outer corners. Teeth of mature males not seen.

Pelvics ovoid, reaching rearward only a little beyond posterior corners of pectorals; their outer and posterior corners well rounded, with posterior and inner margins merging in evenly convex contour; anterior margin about 90–110 % as long as distance from its own origin to rear tip of longest ray of pelvic. Claspers of mature males not seen.

Color. Recently caught specimens (not seen by us) are described as having upper surface brown, sometimes yellowish or olivaceous, either plain or with darker spots, or uniform pale gray. Lower surface pure or yellowish white; ventral tailfold and dorsal keel black.

Size. This has long been known as one of the larger members of its genus. An early account[105] credits it with a width up to five or six feet and a tail up to 11 feet long, while the claspers of a male about 450 mm wide were still rudimentary. The size at birth is not definitely known, but probably it is somewhat greater than 150 mm, for embryos up to 133 mm broad in our Study Material (p. 365) still bear small yolk sacs.

Developmental Stages. Embryos 103–133 mm wide with yolk sac still attached (see Study Material) resemble their parents closely in form of disc and in having the lower tailfold already formed though narrower. However, their skins are perfectly smooth (p. 367), while their tails are slightly longer relatively (about 2.7 times as long as disc) and hair-fine toward the tip.

The number of young that a female may set free at one time has not been recorded, but it is likely that six embryos in the Harvard Museum of Comparative Zoology may

105. Bloch and Schneider, Syst. Ichthyol., 1801: 361.

have come from the same mother, since they were catalogued together and are all of about the same size.

Habits. Nothing whatever is known of the habits or diet of *D. guttata;* probably its way of life is essentially the same as that of other Sting Rays.

Range. Inshore waters in tropical-subtropical latitudes of the western Atlantic, from southern Brazil to the West Indies and southern part of the Gulf of Mexico.

Details of Occurrence. Localities from south to north where the presence of this particular Ray has been positively established are: Santos, Rio de Janeiro, Cannaviera, Bahia, and the region of the mouth of the Amazon, in Brazil; Cayenne in French Guiana; Surinam (Dutch Guiana); Venezuela; Colón, Panama; Grenada; and the north shore of Cuba at Havana. It has been stated that its range extends to "Florida,"[106] but we find no warrant for this in any capture actually recorded. Judging from the geographic distribution of these localities, *D. guttata* is to be expected anywhere in suitable localities from the region of Rio de Janeiro to the Caribbean and southern Gulf of Mexico. It has been described as common near Rio de Janeiro, but nothing is known of its numbers elsewhere.

Synonyms and References:

Raja tuberculata Lacépède, Hist. Nat. Poiss., 4° Ed., in Buffon, Hist. Nat., *2* [An. VIII], 1799–1800: 104, 106, pl. 4, fig. 1 (descr., ill. of young, Cayenne, French Guiana); Shaw, Gen. Zool., *5*, 1804: 290, pl. 137, upper fig. (ident. by descr. and ref. to Lacépède, 1799–1800, S. Amer.).

Raja guttata Bloch and Schneider, Syst. Ichthyol., 1801: 361 (diagn., size, S. Amer.).[107]

Trygon gymnura Müller, Erman's Reise, 1835: 25, pl. 13 (ill., Rio de Janeiro); Müller, Faunus, Z. Zool., Vergl. Anat., herausg. Gistel, N. S. *1*, 1837: 40 (descr. by ref. to Müller, 1835, Rio de Janeiro, ident. suggested with *Raja tuberculata* Lacépède 1799–1800).

Trygon jabebara Müller and Henle, Plagiost., 1841: 160 (descr., Brazil).

Trygon sabina (in part) Müller and Henle, Plagiost., 1841: 163 (Raie tuberculée Lacépède 1799–1800 and *Trygon gymnura* Müller 1835 included in synonymy).

Trygon (*Trygon*) *tuberculatus* Duméril, Hist. Nat. Poiss., *1*, 1865: 605 (descr., Brazil).

Trygon tuberculata (in part) Günther, Cat. Fish. Brit. Mus., *8*, 1870: 480 (descr., Brazil, but *Trygon sabina* Lesueur 1824 included in synonymy).

Dasyatis tuberculatus Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 48 (descr., listed, Florida to Brazil).

Dasibatis tuberculata Garman, Bull. U. S. nat. Mus., 16, 1883: 66 (descr., color, Cannavierias, Para, Bahia, Rio de Janeiro, Surinam [Dutch Guiana]).

Trygon tuberculata Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, W. Indies); Goeldi, Bol. Mus. Paraense, *2*, 1898: 455, 488 (listed, lower Amazon).

Dasybatus tuberculatus Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 99, pl. 41, 42 (mucous canals).

Dasyatis (*Dasybatus*) *gymnura* Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 84 (descr., Surinam [Dutch Guiana] to Brazil; Grenada by ref. to Günther, 1870); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, Surinam [Dutch Guiana] to Brazil).

Dasyatis gymnura Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 188, 209 (descr., size, nos., refs., Rio de Janeiro); Starks, Stanford Univ. Publ., Univ. Ser., 1913: 6 (listed, Para, Brazil); Fowler, Proc. Acad. nat. Sci. Philad., *67*, 1915: 543 (listed, Grenada); Ribeiro, Rev. Mus. paul., 10, 1918: 708 (listed, Santos, Brazil); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 43 (same as Ribeiro, 1907).

Trygon guttata Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range).

106. Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 48.

107. Although the diagnosis of *R. guttata* by Bloch and Schneider is brief, their characterization of its head as "cordiformi" and of its tail as "pinnata," with their statement that it grows to a breadth of 5–6 feet and that its tail is twice as long as its body, seems sufficient for its identification.

Dasybatus (*Dasybatus*) *guttatus* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 391, pl. 71, figs. 1, 2 (descr., ill. skel., Brazil to W. Indies).

Dasybatus guttatus Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 78 (descr., size, Colón); Delsman, Mém. Mus. Hist. nat. Belg., (2) Fasc. 21, 1941: 65 (listed, mouth of Amazon).

Dasyatis guttatus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (listed, Surinam [Dutch Guiana] to Brazil, Grenada); Howell-Rivero, Proc. Boston Soc. nat. Hist., *41*, 1936: 50 (Havana, Cuba); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Panama); Baughman, Copeia, 1946: 42–43 (ref. by Günther, 1870 to Lake Champlain erroneous); Boeseman, Zoöl. Meded., *30* (2), 1948: 33 (descr., discuss., cf. *sabina*; Surinam [Dutch Guiana]).

Probable Synonyms:

Trygon osteostica Müller, in Erman's Reise, 1835: 25, pl. 14 (descr., color, ill., Rio de Janeiro); Müller, Faunus, Z. Zool., Vergl. Anat., herausg. Gistel, N. S. *1*, 1837: 41 (same as Müller, 1835; *T. osteostica* Müller 1835 has commonly been placed in the synonymy of *Dasyatis sabina*, but it probably referred to *D. guttata* Bloch and Schneider 1801, as pointed out in discussion by Boeseman [Zoöl. Meded., *30* (2), 1948: 33–37]).

Doubtful Synonym:

Trygon sabina (in part) Müller and Henle, Plagiost., 1841: 163 (Brazil and Surinam [Dutch Guiana] specimens perhaps actually *guttata*).

Not *Raia tuberculata* Bonnaterre, Tabl. Encyc. Meth. Ichthyol., 1788: 3 (a Skate of the genus *Raja*, probably equals *R. fullonica* Linnaeus 1758).

Dasyatis sabina (Lesueur) 1824

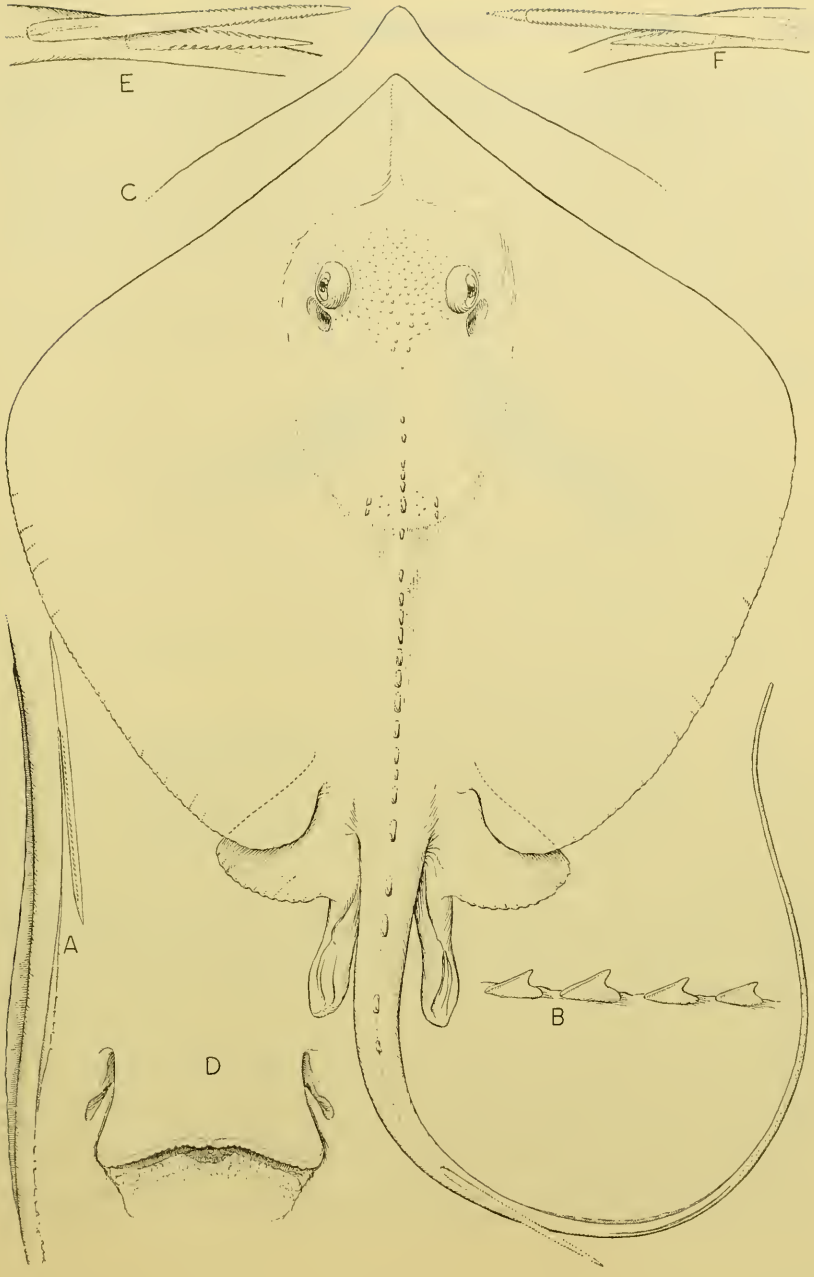
Figures 88, 89

Study Material. Forty-four specimens, 130–390 mm broad, in collections of the Harvard Museum of Comparative Zoology and the U. S. National Museum, from: Caribbean Sea; Gulf of Campeche, Mexico; Galveston, Oso Creek, Corpus Christi Bay, and Matagorda Bay, Texas; Barataria Bay and Bayou Fifi, Louisiana; Mobile, Alabama; New Smyrna, Port Orange, St. Augustine, mouth of the St. Johns River, and Amelia Island, Florida; Charleston, South Carolina; Beaufort and Carteret County, North Carolina; and Willoughby Point, Virginia.

Distinctive Characters. The only western Atlantic Rays with which *D. sabina* might possibly be confused are the other representatives of its own family (Dasyatidae). It is separable at a glance from *Himantura schmardae*, *Dasyatis say*, *D. americana*, and from the river Rays of the genus *Potamotrygon* by its projecting triangular snout. It is distinguished from small specimens of *D. centroura* by its somewhat more prominent snout and by the more broadly rounded outer corners of its disc.[108] Specimens with their

108. There could be no danger of confusing the adults of *D. sabina* with those of *D. centroura*, so much larger are the latter and so much more prominent is their dermal armature.

FIGURE 88. *Dasyatis sabina*, adult male, 270 mm wide, from Amelia, Florida (Harv. Mus. Comp. Zool., No. 121). *A* Side view of middle part of tail of same to somewhat larger scale. *B* Tubercles from mid-dorsal row of same, about 1.5×. *C* Outlines of snout of another male, 230 mm wide, from St. Augustine, Florida (Harv. Mus. Comp. Zool., No. 125). *D* Mouth and nostrils of female, 277 mm wide, from New Smyrna Beach, Florida (Harv. Mus. Comp. Zool., No. 36403), about 1×. *E* Dorsal view of tail spines of female, 177 mm wide, and *F* of female, 162 mm wide, both from Galveston, Texas (Harv. Mus. Comp. Zool., No. 36413), about 1.5×.


E
F
C
A
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D

tails intact are further separable from all of the foregoing, except *D. say*, by the presence of a well developed longitudinal cutaneous fold along both the upper and lower surfaces of their tails. *D. sabina* resembles *D. guttata* somewhat in the shape of the anterior part of its disc, but the former is easily recognized from the latter by: its deeply concave nasal curtain (cf. Fig. 88D with 86G); the more broadly rounded outer corners of its disc; the presence of a cutaneous tailfold above as well as below; and, in the case of half-grown specimens or older, the tubercle-strewn area on its disc is relatively much less extensive, and the mid-dorsal tubercles on the base of the tail are not noticeably larger than those on the posterior part of the disc.

Description: Proportional dimensions in per cent of extreme breadth of disc. Male, 229 mm broad, and female, 348 mm broad, from Florida (Harv. Mus. Comp. Zool., Nos. 125 and 84 respectively).

Disc: vertical length 96.7, 101.0.

Snout length: in front of orbits 25.3, 26.7; in front of mouth 26.2, 26.1.[109]

Orbits: horizontal diameter 7.0, 7.0; distance between 9.6, 10.0.

Spiracles: length 5.7, 6.6; distance between 15.3, 18.1.

Mouth: breadth 8.3, 8.9.

Exposed nostrils: distance between inner ends 9.8, 9.8.

Gill openings: lengths, 1st 2.8, 3.7; 3rd 3.1, 3.7; 5th 2.2, 2.6; distance between inner ends, 1st 19.2, 21.8; 5th 11.8, 13.8.

Pelvics: anterior margin 20.5, 17.8.

Distance: from tip of snout to center of cloaca 87.5, 93.0; from center of cloaca to origin of caudal spine 50.7, 46.0.

Disc in both sexes rhomboid, varying from about as long as broad to a little broader than long (maximum about 1.1 times as broad as long); snout projecting as a broad-based triangle with pointed tip; maximum anterior angle in front of spiracles about 107–122°; outer corners broadly rounded and posterior margins moderately convex; anterior margins concave (in varying degree) opposite eyes and spiracles. Axis of greatest breadth about 45 % of distance rearward from snout toward posterior limits of disc. Tail noticeably depressed dorsoventrally and oval in cross section anterior to spine but approximately round posterior to spine; extremely slender toward tip; more or less of the posterior part often lost, the remaining part more or less thickened posterior to spine with healing of terminal wound; upper surface of tail with a low but definite membranous fold or thin-edged keel varying in prominence from specimen to specimen, originating about under tip of tail spine and extending rearward for a distance about as great as that between outer margins of orbits; hardly more than a ridge in newborn specimens, but usually only a little narrower than height of tail at midpoint of fold on adults; lower surface of tail with a similar but longer and usually somewhat broader fold originating a little posterior to origin of tail spine and

109. In two females and a male, with shorter snouts and with discs 187 to 292 mm broad, from Florida, the length in front of orbits was only 20.6–21.9, that in front of mouth 22.2–23.5.

extending rearward beyond extremity of upper tailfold for a distance about equal to distance between orbits, its maximum width usually a little greater than depth of tail midway of the fold; origins and terminations of tailfolds indefinite. Length of tail from center of cloaca 1.7–2.6 times as great as distance from center of cloaca to tip of snout in specimens with tails apparently intact; distance from center of cloaca to tail spine about half as long as that from cloaca to snout.

Tail spine (or spines) more slender than in other western Atlantic species; length of free portion (if fully developed) a little less to a little greater than distance between

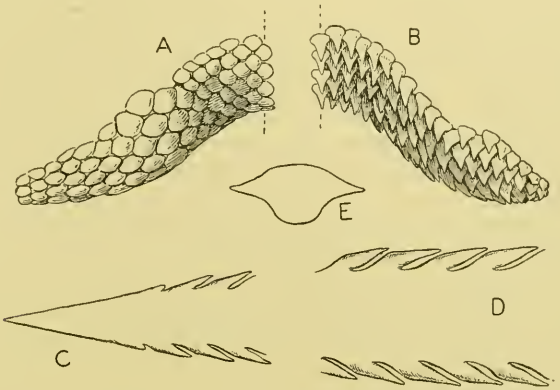

FIGURE 89. *Dasyatis sabina*. *A* Upper right-hand tooth band of female, 268 mm wide, from Florida (Harv. Mus. Comp. Zool., No. 84), and *B* Upper left-hand tooth band of male, 271 mm wide, from Amelia Island, Florida (Harv. Mus. Comp. Zool., No. 121), the symphysis marked in each case by a broken line, about 4×. *C* Tip, *D* Middle part, and *E* Cross section of middle part of tail spine of male shown in Fig. 88, about 9.6×.

outer margins of orbits; total length of spine from origin 1.25–1.5 times that great; maximum breadth of spine about 4.5 % as great as its total length; lateral teeth 32–38 on specimens counted, their outer cutting edges as illustrated in Fig. 89D. Commonly one tail spine, but often two, the replacement spine (in specimens seen) close behind the older one.[110]

Skin, apart from tail spine, perhaps wholly naked on newborn specimens, but a large median tubercle soon develops over pectoral girdle; midline of disc of specimens one-third grown with about 6–8 large tubercles with narrow median crest, sloping anteriorly but vertically truncate posteriorly; larger individuals of both sexes have up to 12–15 tubercles irregularly spaced on disc, 6–8 along anterior part of tail to spine,

110. We have seen six specimens (all about 165 mm broad) from Texas with two spines, in all of which the order of succession was as above. For further discussion, see p. 336.

and 1–2 on each shoulder; halfgrown specimens and older likewise develop an increasing number of low rounded tubercles along median belt of head from a little anterior to orbits rearward past level of spiracles, while small prickles appear in increasing numbers along upper and lateral surfaces of tail posterior to spine; large females (apparently not the males) also have a few small tubercles around outer margins of eyes and spiracles; tubercles are also sparsely distributed from nuchal region rearward along median belt of back. Lower surface entirely smooth in both sexes.

Snout in front of eyes about 1.0–1.4 times as long as distance between outer margins of orbits, its length in front of mouth about 1.9–2.6 times as great as distance between exposed nostrils and 1.0–1.3 times as great as that between inner ends of first gill openings. Eye about 69–76 % as long as distance between eyes and about equal to or a little longer than spiracle. Nasal curtain with posterior margin moderately concave (in varying degree), its free edge finely scalloped, the individual lobelets short, rounded, mostly simple. Upper jaw conspicuously arched forward in both sexes but projecting a little rearward centrally; lower jaw weakly recessed centrally to fit upper jaw when closed. Floor of mouth with three stout papillae centrally, in transverse row, flanked on either side by one slender papilla (perhaps sometimes by two).

Teeth $\frac{28-36}{28-36}$; uppers considerably largest about midway between center of jaw and outer corners, lowers about equally large all along jaw except near outer corners where smaller; those of females and of immature males quadragonal or pentagonal with blunted corners, the functional surface rounded or nearly flat, often more or less scored by wear; those of sexually mature males with long slender cusp except toward corners of mouth; about eight rows in function on upper jaw, 10–12 on lower jaw centrally, and 8–9 toward corners.

Pelvics with broadly rounded posterior margins, reaching beyond rear limits of pectorals for a distance about as great as length of orbit and spiracle combined;[111] anterior margin about as long as distance from its own origin to rear extremity of pelvic or somewhat shorter. Claspers of mature males stout, with simple tips, reaching rearward a little more than halfway from level of axils of pectorals toward origin of tail spine.

Color. Described[112] as brown or yellowish brown above, paler toward margins of disc, sometimes with a dark stripe along midline of back; upper tailfold yellowish brown, the lower fold buff. Lower surface white on small and medium-sized specimens, but disc of larger ones sometimes margined with gray-black from opposite spiracles to axils of pectorals, with posterior parts of pelvics of same hue; tail underneath white or blotched with grayish anteriorly, dark posteriorly.

Relationship to Eastern Atlantic Species. So far as the tailfolds are concerned, *D. sabina* finds its closest affinity with *D. pastinaca* among Sting Rays of the eastern

111. In his original account of the species, which is otherwise sufficiently diagnostic, Lesueur (J. Acad. nat. Sci. Philad., *4*, 1824: 109) describes the pelvics as "long and pointed." Evidently this was an error, for this is not true of any Sting Ray of the western Atlantic except for the recently described *Dasyatis geijskesi* Boeseman 1948. They were correctly represented by Müller (in Erman's Reise, 1835: pl. 14) in his illustration of his supposedly new *Trygon osteostica* from Brazil, which in reality cannot be separated from *sabina*, as Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 398) has pointed out.

112. We have no color notes from life.

Atlantic. But it appears clearly separable from *D. pastinaca* by: a much longer tail (not much longer than disc in *pastinaca*), a relatively longer snout, its more deeply concave nasal curtain, its much more broadly rounded outer pectoral corners, and its somewhat more highly developed upper tailfold. *D. pastinaca* also grows to a considerably larger size at maturity. In general form, *D. sabina* resembles the West African *D. margarita*, but the upper surface of the tail of the latter lacks a fold, while the armature of its disc, with a single large round tubercle in the middle of the back surrounded by numerous small tubercles,[113] is different.

Size. This is the smallest of the long-tailed Sting Rays of the western Atlantic. Embryos ready for birth are reported as having discs about 100 mm wide; gravid females have been described as not much larger than newborn *D. centroura*, i. e., with discs only 160–176 mm wide; a female about 10 inches wide has been reported as having the tail of an embryo protruding from her cloaca and a male of about that same size has been reported as being fully developed. The largest we have seen are a female 390 mm wide and a male of 270 mm in which the claspers apparently are fully formed (Fig. 88). Three specimens with discs 458–610 mm long appear to be the largest recorded.[114]

Developmental Stages. The smallest embryos seen, with discs about 35–36 mm wide, were already of the same shape as their parents, but no information is available as to the stage in development at which the tailfolds become apparent. Females have been found to contain one to three embryos, the males slightly outnumbering the females on an average (56 %), though one litter, three in number, has been reported as consisting of females only.[115]

Habits. This little Sting Ray is encountered most commonly close to the shore line in bays and sounds in depths no greater than seven to eight feet. We find no definite report of it even off open coasts at depths greater than the maximum fished by the shrimp trawlers of Louisiana, about 70 feet.

Observations on the Texas Coast (p. 376) suggest that it tends to avoid temperatures lower than about 16° C (61° F), though it has been taken in water as cold as 13.7° C (56–57° F). It has been recorded in water as warm as 30.5° C (87° F),[116] and to judge from its geographic distribution, it probably finds nothing detrimental in even somewhat warmer situations.

The salinity of the water influences its distribution but little if at all, for it occurs throughout the entire range from fresh water up to full oceanic salinity (upwards of 36 ‰). However, in Texas waters it has been found to be least common where the water is less saline than 10 ‰ and most common in salinities higher than 30 ‰;[117] this makes it doubtful whether *D. sabina* can exist permanently in water that is not at least slightly brackish.

113. For a recent description and illustrations of *D. margarita*, see Fowler (Bull. Amer. Mus. nat. Hist., *70* [1], 1936: 127).
114. Fowler, Proc. Acad. nat. Sci. Philad., *78*, 1926: 249.
115. Breder and Krumholz, Zoologica N. Y., *26*, 1941: 49.
116. Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22.
117. Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22.

Information as to its food is limited to the facts that one taken in Texas waters contained nereid worms, that Chesapeake Bay specimens had eaten crustacea, and that amphipods are an important dietary item for them on the east coast of Florida.[118]

In Louisiana waters, fully ripe males have been captured in February and females giving birth to young in June, and off the coast of Texas small specimens have been taken in spring, summer, and autumn but not in December, January, or February. Thus it appears that young are produced at all times of year except winter.

Available information suggests that it is a year-round resident throughout the warmer parts of its geographic range. This is true, at least locally, along the coast of Louisiana.[119] However, it has been learned recently[120] that most of those on the Texas Coast desert the shallow bays late in the autumn, when the water cools there below about 16° C (61° F), to spend the winter outside in the coastal zone of the open Gulf of Mexico where winter chilling is less extreme. It does not seem likely that this Ray carries out any corresponding thermal migration on the Atlantic Coast south of northern Florida. But the cycle of temperature, as observed at lighthouses and lightships,[121] suggests that specimens penetrating estuarine waters along North and South Carolina may be expected to move either offshore or southward at some time during mid-November or later when the water there usually chills below about 16° C (60–61° F), not returning until some time in April when it warms above that value. *D. sabina* appears to reach the northern fringe of its range solely as a warm-season visitor, for it is reported in Chesapeake Bay only in July and October.

Numerical Abundance. *D. sabina* has been characterized repeatedly as abundant; actually, however, the published counts have not been as large as this might suggest. Thus a series of trawlings in Barataria Bay, well within its center of abundance, as well as in the Gulf of Mexico nearby, yielded an average of only about one specimen per three hauls in one month (June) during 1932 and 1933; catches in a more extensive series of experimental trawlings in Texas waters ranged from 0–54.[122]

Relation to Man. This little Sting Ray, while of no commercial value, is at least less dangerous because of its small size than are its larger relatives.

Range. Coastal waters of the western North Atlantic, often running up into fresh water; Gulf of Mexico and Florida, northward to Chesapeake Bay; reported south to Surinam (Dutch Guiana) and Brazil but probably not on good evidence (p. 377).

Details of Occurrence. The coastal waters of the Gulf of Mexico and of Florida appear to be the center of abundance for *D. sabina*. Thus it is reported as more plentiful than all other Sting Rays combined in the bays of middle and northern Texas and in the neighboring coastal waters outside; it is caught regularly (if in no great numbers) by the shrimp trawlers in the bays of Louisiana as well as in the Gulf offshore. It has been

118. Personal communication from Stewart Springer.
119. They are taken in Barataria Bay at all times of the year.
120. Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 23.
121. Rathbun in Goode, Fish. Fish. Industr. U. S., Sect. 3, Append., 1887: 155–172, 32 charts; Parr, Bull. Bingham oceanogr. Coll., *4* (3), 1933.
122. Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22, 127, table 7.

reported from so many localities along the west coast of Florida, from Pensacola to the southern extremity of the peninsula, and northward along the east coast to the Indian and St. Johns rivers as to prove it universal there in shoal water. It is known also that it swims up rivers far beyond the head of tide, proof of which is found in the capture of one in the Mississippi River more than 200 miles from the Gulf of Mexico, while it is present in Lakes Ponchartrain and Borgne, Louisiana, and occurs in some numbers in the lakes of the St. Johns River, Florida.

Doubtless it occurs to the northward in suitable situations along the coasts of Georgia and South Carolina,[123] for it is the most plentiful of Sting Rays that visit the Beaufort region in North Carolina during the warm months. It ranges as far as Chesapeake Bay, where several specimens were taken in 1921 and 1922. But so far as is known this is the extreme limit of its northward dispersal. The southern limit of its normal range remains to be established, for while *D. sabina* has been credited to Grenada, Dutch Guiana (Surinam) and Brazil, it has been pointed out[124] recently that these reports may have referred to *D. guttata* (p. 365).

Synonyms and References:

Trygon sabina Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 109 (descr., color, Florida); Müller and Henle, Plagiost., 1841: 163 (in part, New Orleans, but descr. of Brazil and Surinam [Dutch Guiana] specimens perhaps for *guttata* Bloch and Schneider 1801); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 543 (descr., Florida by ref. to Lesueur, 1824); Goode, Proc. U. S. nat. Mus., *2*, 1879: 156 (size, Pensacola, Florida); Goode and Bean, Proc. U. S. nat. Mus., *2*, 1879: 120 (St. Johns River and Pensacola, Florida; Galveston, Texas; female with young); Jordan and Gilbert, Proc. U. S. nat. Mus., *5*, 1883: 245 (listed, Galveston, Texas; Lakes Pontchartrain and Borgne, Louisiana; Pensacola, Florida); Bean, Bull. U. S. nat. Mus., 27, 1884: 494 (Lake Monroe, Florida); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, S. Atlant. and Gulf States, U. S.); Lönnberg, Oefvers. Svensk. Vet. Akad. Forh., *51*, 1894: 112 (listed, St. Johns R. and lakes, Florida); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range).

Pastinaca sabina DeKay, Zool. N. Y., 4, 1842: 375 (listed, Florida by ref. to Lesueur, 1824).

Trygon (*Trygon*) *sabina* Duméril, Hist. Nat. Poiss., *1*, 1865: 607 (descr., color, New Orleans).

Trygon tuberculata (in part) Günther, Cat. Fish. Brit. Mus., *8*, 1870: 480 (*sabina* Lesueur included as synonym).

Dasybatis sabina Goode and Bean, Proc. U. S. nat. Mus., *2*, 1880: 344 (listed, W. Florida); Evermann and Kendall, Bull. U. S. Fish Comm., *12*, 1894: 95 (listed, Galveston, Texas).

Dasibatis sabina Garman, Bull. U. S. nat. Mus., *16*, 1883: 68 (descr., Gulf of Florida, and Lake Monroe).

Dasyatis sabina Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 49 (descr.); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 160 (listed, S. Carolina); Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210 (W. Florida); Evermann and Bean, Rep. U. S. Comm. Fish. (1896), 1898: 239 (listed, Indian R., Florida); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (Florida locals.); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 14, fig. 36 (ill.); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 474 (Florida); Radcliffe, Science, N. S. *38*, 1913: 396 (listed, Beaufort, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *72*, 1921: 394 (Florida); Proc. biol. Soc. Wash. *36*, 1923: 28 (Florida); Proc. Acad. nat. Sci. Philad., *78*, 1926: 249 (size, Florida); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 67 (descr., color, size, season, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 35 (genl.); Gudger, Sci. Mon. N. Y., *34*, 1932: 407 (ref. to Fowler, 1926); Gunter, La. Conserv. Rev., *5* (4), 1936: 23, 45 (nos., Louisiana and Gulf of Mexico); Smith, Biol. Rev. (Cambridge), *11*, 1936: 65 (in fresh water); Gunter, Ecol. Monogr., *8*, 1938: 319, 342 (nos., breeding season, Louisiana and Gulf of Mexico); Copeia, 1938: 69 (fresh water, Mississippi

123. Not yet recorded in print.

124. By Boeseman, Zoöl. Meded., *30* (2), 1948: 33–37.

R.); Fowler, Proc. Acad. nat. Sci. Philad., *92*, 1940: 1 (Florida); Breder and Krumholz, Zoologica N. Y., *26*, 1941: 49 (nos., size of embryos, Florida)[125]; Hildebrand, Copeia, 1941: 222 (listed, N. Carolina); Fowler, Fish Culturist, *21*, 1942: 66 (listed, Cuba); Gunter, Amer. Midl. Nat., *28*, 1942: 312 (in fresh water); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 161, 265 (listed, S. Carolina, Florida); Gunter, Publ. Inst. mar. Sci. Texas, *1*, 1945: 22, 126, 127 (nos., season, temp., sal., size, Texas bays, and Gulf of Mexico); Boeseman, Zoöl. Meded., *30* (2), 1948: 33 (cf. *D. guttata*).

Dasyatis (*Dasyatis*) *sabina* Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 84 (descr., color, Florida, including Lake Monroe); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, Florida, including Lake Monroe).

Dasybatis sabina Gill, Smithson. misc. Coll., *52*, 1908: 159, figs. 47, 48 (ills., after Jordan and Evermann, 1900).

Dasybatus (*Amphotistius*) *sabinus* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 396 (descr., size, color, range).

Dasybatus sabinus Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 276 (descr., teeth, color, meas., nos., Beaufort, N. Carolina); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 77 (descr., color, Florida).

Amphotistius sabinus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 29 (refs., range); Chandler, Proc. U. S. nat. Mus., *83*, 1935: 125 (listed, Galveston Bay, Texas).

Dasyatis (*Amphotistius*) *sabinus* Breder and Krumholz, Zoologica N. Y., *26*, 1941: 49 (nos., size of embryos, Florida).

Doubtful References:

Trygon sabina Müller and Henle, Plagiost., 1841: 163 (descr., color, meas., Brazil and Surinam [Dutch Guiana] specimens; doubtful whether descr. of *D. sabina* Lesueur 1824 or *D. guttata* Bloch and Schneider 1801).

Trygon species *dubia* — Chuco, Poey, Repert. Fisico-Nat. Cuba, *2*, 1868: 457 (Cuba).

Trygon (no specific name), — num. 543, Poey, Enumerat. Pisc. Cubens., 1875–1876: 206; An. Soc. esp. Hist. nat., *5*, 1876: 206 (*sabina* suggested, Cuba).

Dasyatis sabina Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 161 (listed, Newport, Rhode Island, N. Carolina, but ident. doubtful because of large size).

Probably not *Amphotistius sabina* Gowanloch, Bull. La. Conserv. Dep., 23, 1933: 86 (photo, not this species because of large size and shape of disc).

Dasyatis say (Lesueur) 1817

Figures 90, 91, 92

Study Material. Thirty-one specimens, including embryos 78–155 mm wide and free-living specimens 147–780 mm wide, from Rio de Janeiro; off Grand Isle, Louisiana; Apalachicola, St. Vincent Island, and Pensacola, Florida; Fort Macon and Beaufort, North Carolina; Chesapeake Bay; Atlantic City and Beesleys Point, New Jersey; in Harvard Museum of Comparative Zoology and U. S. National Museum.

Distinctive Characters. The presence of a well developed fold on the upper surface as well as the lower surface of the tail, easily seen even on small specimens, is enough to separate this species from all other salt-water Sting Rays of the western Atlantic, except for occasional specimens of *D. sabina* that have the folds larger than is usual for that species.[126] And there is no danger of confusing *D. say* with the latter, so widely do the discs of the two species differ in shape (cf. Fig. 90 with 88). Specimens of *D. say* that have lost their tails are easily separated from *D. guttata* by the shape of the anterior margins of the disc (cf. Fig. 90 with 86); half-grown and larger specimens are

125. Spelled *sabinus*.

126. The width of the fold varies widely in *sabina*, as described on p. 372.

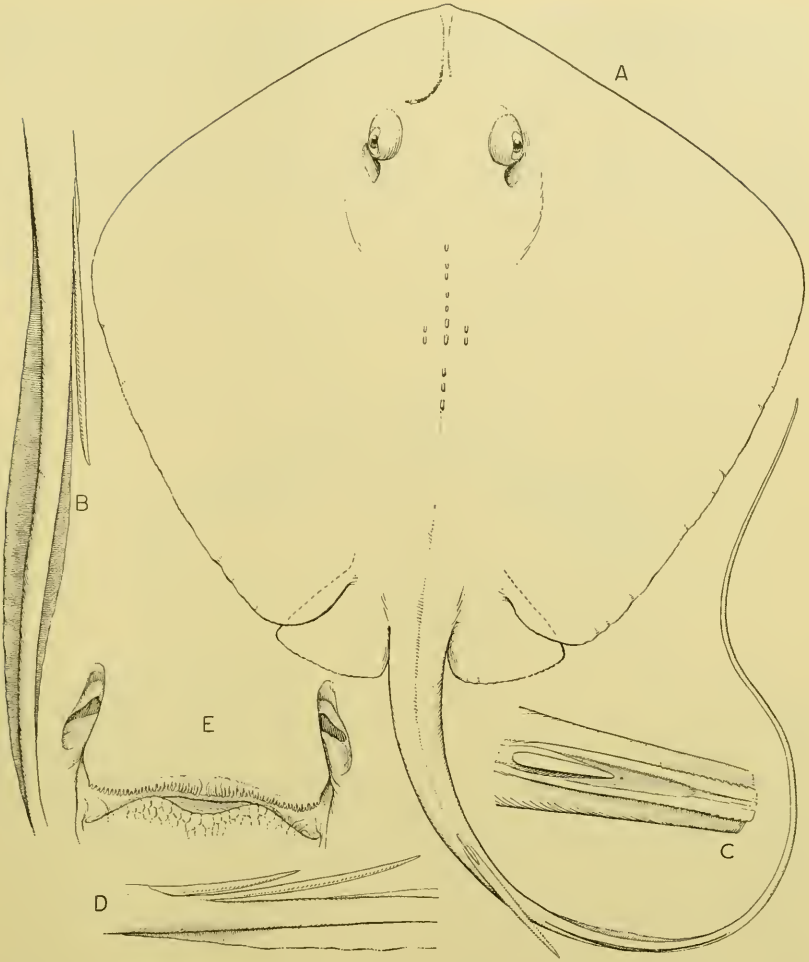

FIGURE 90. *Dasyatis say*. *A* Female, 280 mm wide, from Apalachicola, Florida (U. S. Nat. Mus., No. 127289). *B* Side view of middle part of tail of same, about 0.9×. *C* Dorsal view of newly formed tail spine, as well as base of fully formed spine of same, about 1.7×. *D* Side view of tail spines of male, 260 mm wide, from Beaufort, North Carolina (U. S. Nat. Mus., No. 54895), about 0.9×. *E* Mouth and nostrils of female, 482 mm wide, from St. Vincent Island, Florida (U. S. Nat. Mus., No. 123625), about 0.9×.

further differentiated from *D. guttata* by the different dermal armature (cf. Fig. 90 with 86). Close examination is needed to distinguish a tailless *D. say* from *D. americana* or

D. centroura of corresponding sizes. But the posterior corners of the disc are much more broadly rounded in *D. say* than in either *D. americana* or *centroura;* also, in *D. say* the distance between the inner ends of the second pair of gill openings is invariably somewhat longer than the distance from the front of the lower jaw to the tip of the snout, whereas in *D. americana* it is appreciably less than that, and in *D. centroura* it is only about as long as the length of the snout in front of the mouth. The smoothness and regularly angular anterior contour of the discs of *D. say* that have lost their tails separate them sharply from *Himantura schmardae*, in which the disc is covered with small tubercles (p. 392) and is regularly arcuate anteriorly.

Description. Proportional dimensions in per cent of extreme breadth of disc. Male, 285 mm wide, from Florida (Harv. Mus. Comp. Zool., No. 36402). Female, 780 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 991).

Disc: vertical length 85.4, 89.7.

Snout length: in front of orbits 14.9, 16.8; in front of mouth 16.8, 15.9.

Orbits: horizontal diameter 6.5, 6.0; distance between 9.1, 9.2.

Spiracles: length 7.4, 8.2; distance between 16.8, 16.7.

Mouth: breadth 7.7, 9.0.

Exposed nostrils: distance between inner ends 8.8, 9.0.

Gill openings: lengths, 1st 3.3, 3.7; 3rd 3.3, 4.3; 5th 2.3, 2.7; distance between inner ends, 1st 19.7, 23.6; 5th 13.0, 15.8.

Pelvics: anterior margin 17.9, 17.3.

Distance: from tip of snout to center of cloaca 77.6, 82.7; from center of cloaca to origin of caudal spine 34.0, 38.5.

Disc rhomboid, 1.1–1.2 times as broad as long in both large and small specimens; snout hardly projecting from general contour;[127] maximum anterior angle in front of spiracles about 130°; the anterior margins nearly straight or weakly convex; outer corners rounded, but much more narrowly so than in *D. sabina;* posterior margins weakly convex, increasingly so rearward; posterior corners broadly and evenly arcuate. Axis of greatest breadth 35–40 % of distance rearward from tip of snout toward posterior limits of disc. Tail moderately depressed dorsoventrally anterior to spine, thus oval in cross section; circular in cross section from spine to rear end of lower tailfold; slightly depressed thence rearward; upper tailfold originating either a little anterior to tip of tail spine when latter is laid back or under it, depending on length of spine, increasing gradually to maximum width about midway of its length and then decreasing rearward to merge insensibly with general outline of tail; maximum width of upper fold about equal to thickness of tail at same point; its length about 2.5 times as great as distance between spiracles; lower tailfold nearly uniform in width throughout most of its length, its maximum width a little greater than thickness of tail at same point and a little greater than width of upper fold; origin of lower fold

127. *D. say* falls with *D. americana* and *D. centroura* in this respect and differs correspondingly from *D. sabina* and *D. guttata.*

about under origin of tail spine, its rear termination varying from about under rear termination of upper fold to a point posterior to latter by a distance about half as great as length of upper fold; length of tail from center of cloaca about 1.8–2.3 times as great as distance from center of cloaca to tip of snout in embryos and about 1.8 times after birth if intact.

One or two tail spines, or perhaps more, the replacement spine developing anterior to the older one on specimens seen; when fully developed, maximum length of free portion of spine (or spines) is about 50–60 % as great as, and total length from origin about equal to, distance between outer margins of orbits; greatest breadth of spine

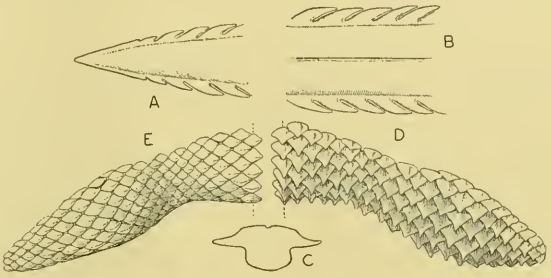

FIGURE 91. *Dasyatis say*. *A* Tip, *B* Middle and *C* Cross section of middle of tail spine of male, 615 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 989), about 2.5×. *D* Upper left-hand tooth band of same, about 1.6×. *E* Upper right-hand tooth band of female, 991 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 991), about 1.3×.

5.5–6 % as great as its total length; 60 lateral teeth on each side on specimen counted, their outer cutting margins arcuate.

Upper surface of disc and tail of young specimens, up to about 220 mm wide, smooth except for tail spines; a row of small to medium tubercles, with median crest sloping anteriorly, soon appearing along midline of back, first over pectoral girdle, next forward to nuchal region, then rearward onto tail nearly to spine; also 1–2 on each shoulder, the one anterior to the other. With growth this median row is replaced anterior to pectoral girdle by 2–3 irregular rows of smaller rounded tubercles; 1–2 shorter rows of large tubercles develop on each shoulder, and the midrow becomes less regular in spacing posterior to pectoral girdle with the loss of individual tubercles, especially in females, until on some mature specimens only two large conical ones remain near the tail spine. Median belt of head anterior to eyes more or less roughened with small prickles on some large specimens, as are outer posterior parts of disc on some at maturity; pelvics smooth in both sexes, but margin of upper tailfold and upper and lateral sides of tail rearward from midpoint of upper fold more or less prickly on large specimens. Lower surface of disc and of tail and lower tailfold smooth at all stages in growth.

Snout in front of eyes about 75–80 % as long as distance between outer margins of orbits on young, increasing to about 85 % on adults; its length in front of mouth about 1.8–2.1 times as great as distance between exposed nostrils and about 85–90 % as great as distance between first gill openings in young, 65–70 % as great in adults. Eyes about 65–70 % as long as distance between them and about 75–90 % as long as spiracle. Distance between inner ends of first gill openings about 2.2–2.6 times as long as distance between exposed nostrils; distance between inner ends of fifth gills about $^2/_3$ as long as distance between inner ends of first gills. Posterior margin of nasal

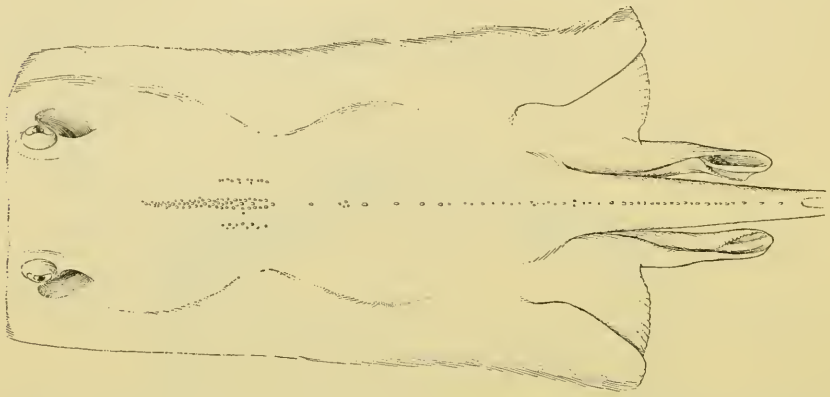

FIGURE 92. *Dasyatis say*. Midbelt of back from eye to origin of tail spine of adult male, 615 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 989), showing mid-dorsal and scapular tubercles as well as claspers.

curtain nearly straight, its free edge finely fringed, the individual marginal lobelets simple or bifid. Upper jaw moderately arched forward in females, more strongly so in mature males but projecting a little rearward centrally; lower jaw weakly recessed in midline to correspond. Floor of mouth with a transverse series of three stout papillae centrally; another smaller papilla on either side.

Teeth[128] $\frac{36-50}{36-56}$; uppers largest about midway between center of jaw and outer corners; lower teeth about equally large in all series, except somewhat smaller near outer ends of tooth band; teeth of females and immature males quadrangular with blunted corners, about as broad (transversely) as long (anteroposteriorly), the functional surface weakly rounded or more or less irregular from wear; those of mature males with low and broadly triangular cusp, largest in the youngest rows. About 6–7 rows in function on upper jaw; 10–12 rows exposed centrally on lower jaw, 6–7 rows near outer corners.

Pelvics reaching rearward only a little, if at all, beyond rear limits of pectorals,

128. Counted along widest part of tooth band.

their anterior and posterior margins nearly straight, inner margin weakly convex; outer corners abrupt, and posterior corners a little more broadly rounded; length of anterior margin about as great as distance from its own origin to inner rear corner. Claspers of mature males with simple tips, reaching rearward nearly to origin of tail spine.

Color. Very young specimens described[129] as yellowish or light brown above; adults grayish-, olivaceous- or reddish-brown or dusky green above, sometimes with bluish spots of various shapes; often darker near outer and posterior margins; sometimes narrowly edged with white; terminal part of tail and upper tailfold dusky or black. Lower surface whitish or pure white, sometimes with irregular dark blotches on tail and disc or with pectorals and pelvics irregularly margined with dusky in large specimens.[130]

Relationship to Eastern Atlantic Species. Among the five species of *Dasyatis* of the eastern Atlantic, *D. say* is rather sharply separated from *D. margarita*, *D. pastinaca*, *D. rudis*, and *D. violacea* by the anterior contour of its disc and by its much wider upper tailfold; from *D. aspera* by the same features that separate it from *D. centroura* (p. 380).

Size. Large specimens in French Guiana are described as averaging about one meter in width, which seemingly is close to the maximum, 36 inches being the greatest breadth recorded for any North American specimen. A male with large claspers in our Study Material is 24 1/2 inches wide, and the smallest female so far recorded as containing eggs or as having a dilated uterus was 13 inches wide.[131] A female 27 inches wide from the Virginia Coast weighed 35 pounds.[132]

Developmental Stages. Only the left-hand ovary and uterus have been found functional in the majority of gravid females examined, though both uteri have been found to contain embryos in occasional specimens;[133] in fact, it appears to be the general rule among Sting Rays that only one of the two ovaries and uteri function at a time. As the eggs ripen, the uterus enlarges and its wall becomes covered with slender red villi about two cm long and slightly enlarged at their tips. During later development the embryos lie bathed in a creamy yellow fluid which is probably secreted by the villi and which seemingly provides nourishment to the embryo in addition to that provided from the yolk sac, for the large intestine of larger embryos has been found filled with a similar substance. It has been suggested that this so-called "milk" is absorbed at first through the gill filaments and later through the spiracles. But no exact observations have been made, nor is it known at what stage in development the mouth becomes functional. The period of gestation is not known, but eggs 12–15 mm in diameter have been found in a female which at the same time had embryos of the next older generation nearly ready for birth. Females have been found to contain two, three or four embryos; in one case three males and one female. Gravid females with embryos nearly ready for

129. We have no color notes from life.
130. The largest of both sexes that we have seen show this dark edging below.
131. Gudger, Proc. biol. Soc. Wash., *25*, 1912: 146. 132. Hamilton and Smith, Copeia, 1941: 175.
133. This account of the uterus and of its contents is adapted from observations by Gudger (Proc. biol. Soc. Wash., *25*, 1912: 144; *26*, 1913: 99).

birth have been reported only during the warm season in the northern sector of its range (North Carolina and Virginia). But it is likely that young are produced at all times of the year in subtropical-tropical latitudes.

Young, born prematurely, as often happens when gravid females are caught, "moved around rather freely but had difficulty in staying right side up . . . One, however, when placed in the normal position on the bottom of the aquarium, showed, in the lifting of the body and in the motion of the hinder edges of the pectorals, the characteristic breathing movements of the adult."[134] The fact that a young specimen, only 6.75 inches wide, lashed violently with its tail when handled, is evidence that this protective act is instinctive from birth.

Embryos nearly ready for birth are described as about 5.0–6.25 inches wide, suggesting that the young are born when they are about 6–7 inches wide. And "it would seem that the larger the mother the larger the young to which she gives birth."[135] Of five specimens, 147–161 mm broad (5 3/4–6 3/8 in.), in the collection of the Harvard Museum of Comparative Zoology, one had a small unhealed umbilical scar, one had a healed scar, and three had small yolk stalks. All of these were evidently ready for birth or were newborn.

The upper and lower tailfolds are described as already well developed even before birth,[136] hence identification of even the smallest free-living specimens is easy.

Habits. Dasyatis say, like other Sting Rays, spends most of its time lying on bottom, usually partially buried in sand or mud, with only the eyes and the spiracles exposed, and it is so motionless that it is apt to escape notice unless disturbed. In situations where the flats over which they feed are laid bare at ebb tide, as along the North Carolina Coast, they move in and out with the rise and fall of the water. They are much more active on occasion than might be expected from their sedentary habits, for individuals that take part in the summer migration northward along the United States Coast (p. 385) carry out journeys of some hundreds of miles. When on the move, they often break the surface with rapid splashes of the pectorals, first flapping rapidly ahead for a short distance and then slackening to settle down again out of sight; sometimes their tails lash out above the water, a procedure that makes them conspicuous on their arrival in the bays and inlets along the Middle Atlantic Coast of the United States.[137]

Throughout its range *D. say* is much more plentiful in water of only a few inches down to 8 or 10 feet than in water deeper than that. We have seen them taken from pound nets in a depth of about 30 feet in lower Chesapeake Bay but, other than this, 20 feet[138] is the greatest depth from which they have been actually recorded. For such of the stock as takes part, the yearly migration northward to the Middle Atlantic Coast of the United States entails the crossing of considerably deeper waters, and it may prove that the regular range of *D. say* off open beaches extends deeper than is recognized at present.

134. Gudger, Proc. biol. Soc. Wash., *25*, 1912: 144.
135. Gudger, Proc. biol. Soc. Wash., *25*, 1912: 145.
136. Hamilton and Smith, Copeia, 1941: 175.
137. For a vivid account, see Hamilton and Smith (Copeia, 1941: 175).
138. Hamilton and Smith, Copeia, 1941: 175.

Like other Sting Rays, *D. say* is a bottom feeder. Specimens taken in estuarine waters near Beaufort, North Carolina, contained chiefly annelid worms and small bivalves, including many detached siphons of the latter, probably bitten off while protruding from the sand; they had also eaten lesser amounts of gastropods, amphipods, shrimps, crabs and fish. Otherwise we know only that in French Guiana it eats small mollusks, as well as mud, no doubt for the animals contained therein.

Doubtless this species is a year-round resident throughout the tropical-subtropical part of its habitat northward to middle Florida. But it visits the more northerly sector of its range along the Atlantic Coast of the United States only as a warm-season migrant, appearing on the North Carolina Coast early in May and remaining there all summer. At least some specimens reach the mouth of Chesapeake Bay and the adjacent coast nearly as early as they reach North Carolina, for they have been reported on May 16[139] from Smith's Island, Virginia. June 10 is the earliest recorded capture from any part of the coast farther north.[140] Apparently such of the stock as visits Delaware Bay and the coast of New Jersey have withdrawn again by early autumn, the few dated records published thus far being for June, July, and August. However, they are plentiful during late September and early October in the lower part of Chesapeake Bay. Available information suggests that it is not until the latter part of October that they move southward from the North Carolina Coast, where some linger until November. It is also likely (to judge from winter temperatures) that *D. say* withdraws from the Louisiana and Texas shores at some time during early winter, but definite information is lacking.

The dates of arrival of *D. say* in the vicinity of Cape Lookout, North Carolina, and in the general vicinity of Chesapeake Bay (p. 385) suggest that its northward dispersal in spring keeps pace with the northerly advance of the isotherm of about 19–20° C (about 66–68° F). The time of its disappearance from the northern part of its range in autumn suggests that it tends to withdraw as soon as the water cools to approximately this same temperature. And its presence in shallow water within the tropics, as in French Guiana, shows that it is at home in the highest temperatures normally occurring anywhere along the western shores of the Atlantic or of the Caribbean.

D. say differs from *D. sabina* in that it has never been reported from fresh water. But it does occur over a wide range of salinities, from brackish situations as in the Indian River, Florida, to salinities of 32–33 ‰ along the open coasts of the Middle Atlantic United States, and among the West Indies it appears in water that is considerably more saline than that.

Numerical Abundance. For Florida and North Carolina waters *D. say* has been termed abundant, and it has been referred to as common northward even to Chesapeake Bay. But the only precise information as to its actual numbers anywhere is that we have seen as many as 40 individuals taken in one lift of a pound net in Lynnhaven Roads, Virginia.[141]

139. Fowler, Occ. Pap. Mus. Zool. Univ. Mich., *56*, 1918: 16. 140. Sea Island City, New Jersey.
141. Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 66.

Relation to Man. D. say is probably a more serious source of danger to fishermen and bathers on the Atlantic Coast of the United States than any other Ray, since it is generally more plentiful than either of the other large Sting Rays that coexist with it in one part of its range or another. Because of the danger from their spines, fishermen who hook them accidentally or who find them in their nets usually cut off their tails before throwing them back into the water. We think it likely that at least some of the tailless specimens that have been recorded in scientific literature (we have seen some also) have been mutilated in this way rather than by large Sharks, though Sting Rays have long been known to contribute to the diet of the latter.

Range. Coastal waters of the western Atlantic from southern Brazil, perhaps Uruguay and northern Argentina, northward regularly to Chesapeake Bay and Virginia, not uncommonly to New Jersey, and accidentally to southern Massachusetts.

Details of Occurrence. This Ray is to be expected in suitable situations all along the South American Coast from middle or southern Brazil to the mainland shore of the Caribbean, and throughout the general region of the Greater and Lesser Antilles, for it is recorded definitely or with reasonable probability[142] from Rio de Janeiro, Bahia, and Natal in Brazil; from French Guiana where it is so plentiful as to be a menace to fishermen; from British Guiana; from Martinique, Turks Island, Puerto Rico, Santo Domingo, Haiti, Jamaica, and Cuba.

Curiously enough, nothing whatever is known of its status along the western shores of the Caribbean or along the Mexican coastline of the Gulf of Mexico, though it may occur there. There are only two records for it from Texas[143] and one from Louisiana.[144] However, we suspect that it is more general in its occurrence around the northern side of the Gulf than the printed record would indicate, for among Sting Rays it is described as ranking second only to the little *D. sabina* along the west coast of Florida.[145] On the east coast of Florida it has been recorded from both Biscayne Bay and Indian River. No doubt it occurs along the coasts of Georgia and South Carolina during the warmer months of the year, though it is not definitely recorded thence, probably due to the paucity of local ichthyological knowledge. In season (p. 385) it has been characterized as the commonest Ray at Cape Lookout, North Carolina, and as plentiful in estuarine situations in the vicinity of Beaufort nearby. On its migrations it must also skirt the northern coast of North Carolina and southern Virginia equally regularly (p. 385), for it is common in the southern parts of Chesapeake Bay (sometimes common enough to be troublesome) and perhaps farther up the Bay as well.[146] Probably it visits the coasts of northern Virginia and Maryland yearly,[147] for fishermen report that large Rays of some sort enter the local bays in July, "their arrival made

142. The published record is more dependable for *D. say* than for other local Sting Rays, because it is easily identifiable.
143. Corpus Christi, and simply Texas.
144. Off Grand Isle (see Study Material, p. 378).
145. Reported from Apalachicola Bay and St. Vincent Island, Pensacola, Tampa Bay, Charlotte Harbor, Englewood, Lemon Bay, and Key West, Florida (see Study Material, p. 378, for the first two of these localities).
146. We have seen it in large numbers at Lynnhaven Roads. For further details as to its status in the Bay, see Hildebrand and Schroeder (Bull. U. S. Bur. Fish., *43*, 1928: *66*).
147. Reported from Cape Charles, Smiths Island and nearby inlets, Chincoteague, and Ocean City.

conspicuous by their habit of swimming and splashing on the surface."[148] However, most of the records of it for the coast of New Jersey[149] have been based on odd specimens only. Although the Paris Museum also has (or had) seven specimens from New York,[150] this Ray has been reported only once from southern New England (Buzzards Bay, Massachusetts), its farthest known outpost in this direction.

We have yet to learn the latitudinal range of *D. say* in the southern hemisphere; while Rio de Janeiro is the most southerly locality where its presence has been positively established, nominal records of *D. pastinaca* from Uruguay and from northern Argentina may have been based on it, in part at least (see Doubtful References, p. 388).

Synonyms and References:

Raja say Lesueur, J. Acad. nat. Sci. Philad., *1*, 1817: 42, pl. not numbered (descr., color, ill., New Jersey).

Trygon sayi Müller and Henle, Plagiost., 1841: 166 (descr., meas.; Martinique, Santo Domingo, New York); Castelnau, Anim. Nouv. Rares Amer. Sud, Poiss., 1855: 103 (listed, Rio de Janeiro, Brazil); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed Atlant. coast N. Amer.); Abbott, in Cook, Geol. N. J., Append. E, 1868: 829 (listed, New Jersey);[151] Poey, Repert. Fisico-Nat. Cuba, *2*, 1868: 456 (color, dermal armature, embryo, Cuba); in Gundlach, An. Soc. esp. Hist. nat., 10, 1881: 350 (listed, Cuba, Jamaica, Puerto Rico with query); Stahl, Fauna Puerto Rico, 1883: 81, 167 (listed, Puerto Rico; not seen); Jenkins, Johns Hopkins Univ. Stud. Biol., *4*, 1887: 84 (nos., Beaufort, N. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, S. Atlant. and Gulf coasts U. S.); Henshall, Bull. U. S. Fish Comm., *9*, 1891: 384 (nos., Florida); Lönnberg, Oefvers. Svensk. Vet. Akad. Forh., *51*, 1894: 112 (listed, Florida); Smith, Rep. U. S. Comm. Fish. (1895), 1896: 175 (listed, Biscayne Bay, Florida); Wilson, Amer. Nat., *34*, 1900: 355 (nos., Beaufort, N. Carolina); Norman and Fraser, Giant Fishes, 1937: 72 (range).

Myliobatis (?) *say* DeKay, Zool. N. Y., 4, 1842: 376 (New Jersey by ref. to Lesueur, 1817).

Myliobatis say Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 514 (diagn., New Jersey by ref. to Lesueur, 1817).

Trygon (*Trygon*) *sayi* Duméril, Hist. Nat. Poiss., *1*, 1865: 603 (descr., New York, Martinique, Haiti, Brazil).

Trygon centroura Yarrow, Proc. Acad. nat. Sci. Philad. [29], 1877: 216 (ident. probable because of nos., Beaufort, N. Carolina).

Dasibatis sayi Garman, Bull. U. S. nat. Mus., *16*, 1883: 69 (descr., color, range, cf. European *D. pastinaca*).

Dasyatis sayi[152] Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 48 (descr., S. Atlant. and Gulf coasts U. S.); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 260 (listed, S. Carolina); Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210 (listed, S. and W. Florida); Evermann and Bean, Rep. U. S. Comm. Fish. (1896), 1898: 239 (nos., Indian R., Florida); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 50 (descr., color, Florida); Evermann and Marsh, Bull. U. S. Bur. Fish., *20* (1), 1902: 65 (descr., Puerto Rico); Bean, Bull. N. Y. St. Mus., 60, Zool. *9*, 1903: 55 (descr., color, New York to Florida and Brazil); Linton, Bull. U. S. Bur. Fish., *24*, 1905: 346 (stom. contents, parasites, Beaufort, N. Carolina); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 189, 210 (descr., photo, refs., New York to Bahia); Smith, N. C. geol. econ. Surv., *2*, 1907: 44 (descr., food, season, nos., danger to fishermen, N. Carolina); Fowler, Rep. N. J. Mus. (1907), 1908: 132 (descr., color, size, New Jersey); Proc. Acad. nat. Sci. Philad., *62*, 1910: 473 (descr., in part, but not Delaware Bay spec., which was subsequently refd. by him [Proc. biol. Soc. Wash., *33*, 1920: 146] to *D. hastata*, equals *D. americana* Hildebrand and Schroeder 1928); Proc. Acad. nat. Sci. Philad., *62*, 1910: 599 (listed, New Jersey);

148. Hamilton and Smith, Copeia, 1941: 175.

149. Cape May, Sea Island City, Atlantic City, Barnegat Inlet, Egg Harbor, and Beesleys Point; see also Study Material, p. 378).

150. Müller and Henle (Plagiost., 1841: 167). These specimens formed part of the collection of some 200 fishes that were sent back from the vicinity of New York between 1815 and 1823 by the French traveller Jacques Gerard Milbert. For an account of his journeys in the northeastern United States and Canada, see his Itinerarie Pittoresque du Fleuve Hudson ... 2 vols., Paris, 1828.

151. Spelled *sayii*.

152. More commonly and correctly spelled *say*.

Gudger, Amer. Nat., *44*, 1910: 401 (eggs, nutrition of embryos, young, season, Beaufort, N. Carolina); Proc. biol. Soc. Wash., *25*, 1912: 144 (diet, habits, ovary and uterus, eggs, nutrition of embryos, size, reactions of newborn., nos., season, Beaufort, N. Carolina); Fowler, Copeia, 2, 1914: [2] (listed, Ocean City, Maryland); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 99 (left ovary functional); Starks, Stanford Univ. Publ., Univ. Ser., 1913: 6 (color, Natal, Brazil); Fowler, Proc. Acad. nat. Sci. Philad., *66*, 1914: 322 (listed, New Jersey); Copeia, 2, 1914: [2] (listed, Maryland); Coles, Proc. biol. Soc. Wash., *28*, 1915: 93 (nos., season, Cape Lookout, N. Carolina); Fowler, Copeia, 27, 1916: 11 (nos., Maryland); Proc. Acad. nat. Sci. Philad., *69*, 1917: 109 (listed, New Jersey); Occ. Pap. Mus. Zool. Univ. Mich., 56, 1918: 16 (listed, Smiths I., Virginia); Proc. Acad. nat. Sci. Philad., *71*, 1920: 300 (listed, Virginia); Proc. biol. Soc. Wash., *33*, 1920: 146 (New Jersey); Nichols, Bull. Amer. Mus. nat. Hist., 44, 1921: 22 (listed, Turks I., W. Indies); Fowler, Proc. Acad. nat. Sci. Philad., *74*, 1922: 6, 7 (listed, Delaware and New Jersey); Ribeiro, Fauna brazil., Peixes, *2* (1) Fasc. 1, 1923: 44 (same as Ribeiro, 1907); Fowler, Copeia, 165, 1927: 89 (Chincoteague, Virginia); Fish Culturist, *6*, 1927: 115 (weight, season, New Jersey); Beebe and Tee-Van, Zoologica N. Y., *10*, 1928: 276 (Haiti, by ref. to Duméril, 1865); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 66 (descr., nos., season, wounds by tail spines, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 35 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn., New York to Brazil); Nichols, Sci. Surv. Puerto Rico, N. York Acad. Sci., *10* (2), 1929: 187 (ill., Puerto Rico by ref. to Poey, 1881); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 32 (descr., Maryland); Gudger, Copeia, 1933: 186 (malformed specimen, Beaufort, N. Carolina); Amer. Mus. Novit., 600, 1933: 10, fig. 9 (pectorals of embryo); Chamberlain, Copeia, 42, 1934: 43 (mutilation by fishermen); Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 77, 250 (descr., meas., habits, danger to fishermen, French Guiana); Smith and Goffin, Copeia, 1939: 236 (Buzzards Bay, Massachusetts); Hamilton and Smith, Copeia, 1941: 175 (swimming, size, weight, nos., uterine villi, functional uterus, no. and size of embryos, depth, Virginia); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 433 (listed, Turks Island, Bahamas).

Dasabatis sayi Evermann and Kendall, Bull. U. S. Fish Comm., *12*, 1894: 95 (listed, Corpus Christi, Texas).

Dasyatis (*Dasyatis*) *say* Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 86 (descr., Brazil to New York); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, Brazil to New York).

Dasibatis pastinaca Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 81 (listed, Rio de Janeiro).

Dasybatus say Fowler, Rep. N. J. Mus. (1905), 1906: 77 (descr., color, New Jersey by ref. to Lesueur, 1817); Rep. N. J. Mus. (1906), 1907: 261, pl. 80 (ill.); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 275 (teeth, meas., uterus and contents, nos., Beaufort, N. Carolina); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 77 (descr., Texas).

Dasyatis centroura Fowler, Proc. Acad. nat. Sci. Philad., *61*, 1909: 407 (Delaware Bay, ident. corrected by Fowler [Proc. Acad. nat. Sci. Philad., *62*, 1910: 473]).

Dasybatus (*Amphotistius*) *say* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 396 (descr.).

Amphotistius say Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (listed, Brazil to New York); Bere, Amer. Midl. Nat., *17*, 1936: 578 (copepod parasites, Lemon Bay, Florida).

Doubtful References:

The following may refer to *D. say*, wholly or in part.

Dasybatis pastinaca Berg, An. Mus. nac. B. Aires, *4* (Ser. 2, *1*), 1895: 15 (listed, vicinity of Montevideo); Devincenzi, An. Mus. nac. Montevideo, (2) *1*, 1920: 130 (listed, Uruguay, by ref. to Berg, 1895); Marelli, Elenc. Sist. Fauna B. Aires, Mem. Ministr. Obras Publ. (1922–1923), 1924: 548 (listed, Montevideo, probably by ref. to Berg, 1895).

Trygon pastinaca Duerden, J. Inst. Jamaica, 6, 1899: 608 (listed, Jamaica); Lahille, Physis B. Aires, *5*, 1921: 63 (listed, Argentina).

Probably not *Dasybatis pastinaca* Devincenzi and Barattini, An. Mus. Hist. nac. Montevideo, (2) *2*, Addend., Album ictiol., 1926: pl. 5, fig. 5 (ill. appears to be *D. guttata*).

Not *Raja pastinaca* Linnaeus, Syst. Nat., *1*, 1758: 232.

Not *Raja centroura* Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 479.

Not *Dasyatis say* Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 473 (Delaware Bay specimens, later refd by Fowler [Proc. biol. Soc. Wash., *33*, 1920: 146] to *D. hastata*, equals *D. americana*, which see, p. 352).

Genus *Himantura* Müller and Henle 1837

Himantura Müller and Henle, Arch. Naturg., *1*, 1837: 400; Charlesworth Mag. Nat. Hist., *2*, 1838: 90; diagnosis but no species mentioned; type species, *Raja uarnak* Forskål 1775, Arabia, designated by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 375).[153]

Generic Synonyms:

Raja (in part) Forskål, Descr. Anim., 1775: viii, 18; for *R. uarnak* Forskål, Arabia; not *Raja* Linnaeus 1758.
Trygon (in part) Cuvier, Règne Anim., *2*, 1817: 136, footnote 2; for *Raja uarnak* Forskål 1775. Arabia.
Pastinachus Rüppell, Neue Wirbelt. Abyssinia, *4*, Fische, 1835: 69; for *Raja uarnak* Forskål 1775; not *Pastinachus* Rüppell 1828.
Leiobatus Bleeker, Ned. Tijdschr. Dierk. Amst. (1863), *1*, 1864: 264; for *Raja uarnak* Forskål 1775; not *Leiobatus* Rafinesque 1810, equals *Rhinobatos* Link 1790, which see, p. 50.
Leiobatis Bleeker, Arch. Neerland. Sci. Nat. Haarlem, *13*, 1878: 36; emended spelling for *Leiobatus* Bleeker 1863.
Dasyatis (in part) Stead, Add. Fish. Fauna N. S. W., *1*, 1907: 2; for *Raja uarnak* Forskål 1775; not *Dasyatis* Rafinesque 1810, which see, p. 340.
Dasybatis Regan, Ann. Natal Mus., *1*, 1908: 242; for *Raja uarnak* Forskål 1775; not *Dasybatis* Blainville (in Vieillot, Faune Franç., Poiss., 1825: 12), equals *Raja* Linnaeus 1758, which see, p. 138.
Himanturus ("subgroup" of *Dasybatus*) Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 375; emended spelling for *Himantura* Müller and Henle 1837.
Himantura (subgenus of *Dasyatis*) Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 403.

Probable Generic Synonyms:

Trygonobatus (in part) Blainville, Bull. Soc. philom. Paris, 8, 1816: 112; for *T. longicaudatus* Blainville (name only), classed by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 406) as equal to *Raja uarnak* Forskål 1775.

Doubtful Generic Synonym:

Brachioptera Gratzianow, Zool. Anz., *30*, 1906: 400; type species, *B. rhinoptera* Gratzianow, Singapore; monstrosity (embryo) with anterior parts of pectorals free from sides of head; probably *Himantura* or *Gymnura* because without caudal folds.

Generic Characters. Tail much longer than disc, its upper surface armed with a large serrate-edged spine (or spines); without well developed longitudinal dermal fold along either its lower or upper surface. Pelvis forming an angle of about 115°, directed forward. Characters otherwise as in *Dasyatis* (p. 340).[154]

Range. Indian Ocean in general; Red Sea; East Indies; Philippines; southeastern coasts of Asia north to Japan; Australia; Melanesia; Micronesia and Polynesia; Pacific Coast of Central America; and western tropical Atlantic.

Species. Some 12 species referable to *Himantura* as here defined are recognized

153. *Himantura* was proposed as a new genus by Müller and Henle in 1837 for Sting Rays in which there is no trace of a "schwanzflosse," but they mentioned no particular species, though they stated later (Charlesworth Mag. Nat. Hist., *2*, 1838: 90) that it included six. In 1865 Duméril, who employed it as a subgenus (Hist. Nat. Poiss., *1*, 1865: 583), referred no less than 14 species to it. But it was not until 1913 that a type was expressly designated for it by Garman, as stated above, under the emended spelling *Himanturus*.

154. This definition for *Himantura* agrees essentially with those of Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 375) and Fowler (Bull. U. S. nat. Mus., 100 [13], 1941: 403), except that it admits species with a low keel on the lower surface of the tail below the spine, an expansion that seems requisite to provide a generic location for *Dasyatis pacificus* Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 262) from Costa Rica, which closely resembles *H. schmardae* of the Atlantic (p. 390) in most other respects. The pelvis of *H. schmardae* is described as having a low triangular median process, directed dorsad (Boeseman, Zool. Meded., *30* [2], 1948: 32). But the pelvis of a specimen we dissected shows no trace of any such projection.

in recent surveys of Sting Rays of the western Pacific-Indian Ocean region and Red Sea,[155] but we think it is likely that final revision will result in a drastic reduction in this number. One species, *H. pacifica* (Beebe and Tee-Van) 1941, is known from Costa Rica on the Pacific Coast of Central America and another, *H. schmardae* (Werner) 1904, from the western tropical Atlantic. The genus seems not to have been encountered in the eastern side of the Atlantic as yet, but it is to be expected along tropical West Africa. The one Atlantic species is included in the Key, p. 343.

Himantura schmardae (Werner) 1904

Figures 93, 94

Study Material. Three immature males, 242–563 mm broad, from Largorema Island and Toro Point, Atlantic Panama, and from the West Indies, in the U. S. National Museum. Also six specimens, male and female, 244–405 mm wide, from near Havana, Cuba, and Carmen, Mexico (Gulf of Campeche), in the Harvard Museum of Comparative Zoology.

Distinctive Characters. The ovate shape of its disc, evenly arcuate in front as well as broadly rounded outwardly, combined with the fact that the upper surface of the disc as well as of the anterior part of its tail is closely and evenly set with small blunt tubercles, with one larger tubercle on each shoulder, make this perhaps the easiest to identify among the long-tailed Sting Rays of the western Atlantic. It is also unique among western Atlantic species in the dichotomously quadriradiate structure of the small tubercles and in the position of the tail spine (or spines) far rearward.

Description. Proportional dimensions in per cent of extreme breadth of disc. Male, 242 mm wide, from Largorema Island, Atlantic Panama (U. S. Nat. Mus., No. 128388). Male, 563 mm wide, from Toro Point, Canal Zone (U. S. Nat. Mus., No. 86071).

Disc: length 97.3, 89.5.
Snout length: in front of orbits 20.7, 19.0; in front of mouth 20.3, 17.0.
Orbits: horizontal diameter 5.2, 3.3; distance between 11.2, 12.0.
Spiracles: length 9.1, 6.4; distance between 17.4, 14.6.
Mouth: breadth 9.1, 7.5.
Exposed nostrils: distance between inner ends 8.3, 8.3.
Gill openings: lengths, 1st 4.1, 3.2; 3rd 3.7, 3.4; 5th 2.5, 3.1; distance between inner ends, 1st 23.2, 20.5; 5th 18.6, 15.0.
Pelvics: anterior margin 20.7, 19.0.
Distance: from tip of snout to center of cloaca 86.1, 80.0; from center of cloaca to origin of caudal spine 80.3, 78.2.

Disc only a little broader than long (about 1.0–1.1 times), ovoid; snout marked only by a low papilla; median sector of anterior contour broadly arcuate, becoming

155. Whitley, Fish. Aust., 1, 1940: 211; Fowler, Bull. U. S. nat. Mus., 100 (13), 1941: 405.

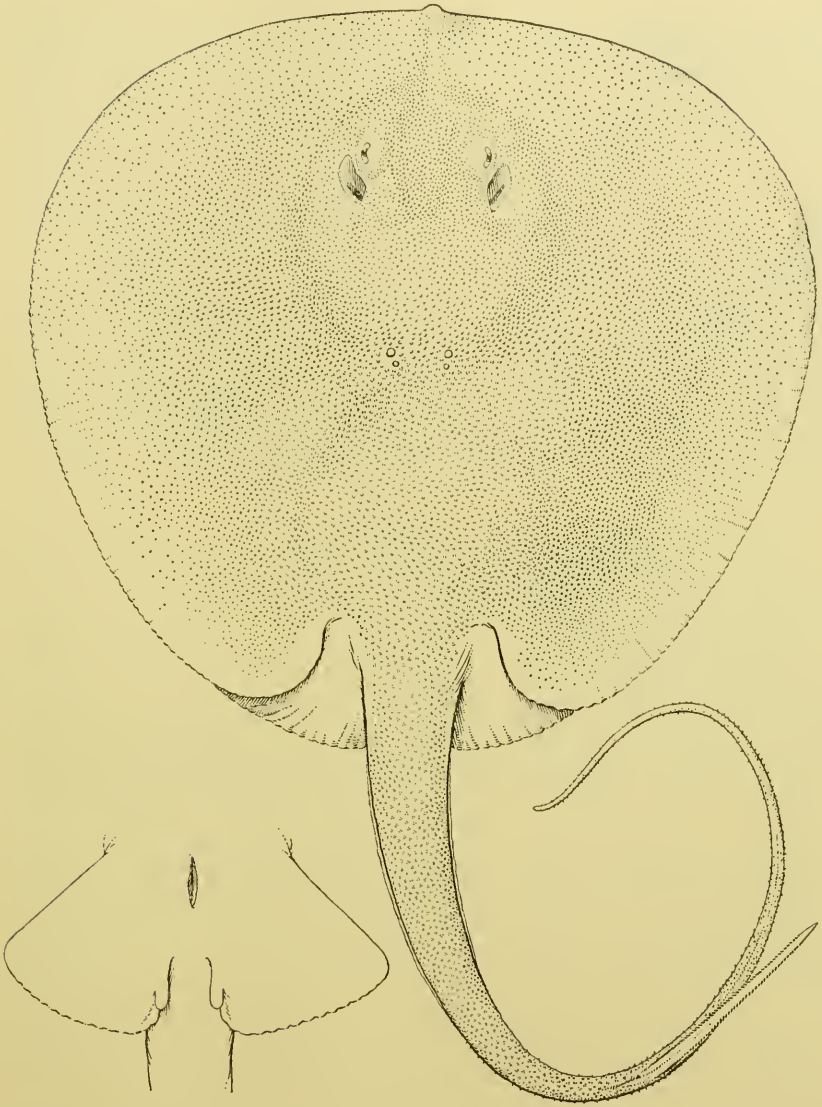

FIGURE 93. *Himantura schmardae*, immature male, 563 mm long, from Toro Point, Panama Canal Zone (U. S. Nat. Mus., No. 86071).

increasingly obtuse with growth until nearly straight across; outer and posterior corners broadly rounded; posterior margins moderately and evenly convex, the inner margins somewhat more strongly so. Axis of greatest breadth 44–49 % of distance rearward from tip of snout toward rear limits of disc. Tail from center of cloaca 1.8–2.0 times as long as body from cloaca to tip of snout; moderately stout anterior to spine,[156] rounded above but only weakly rounded or even flat below on small specimens; narrowing to a whiplash tip; approximately circular in cross section posterior to spine; either side with a low and obscure longitudinal ridge extending from about opposite tips of pelvics to about half the distance toward spine; lower surface of tail with a low ridge extending from below origin of spine past tip of latter for a short distance.

Tail spine originating posterior to center of cloaca by a distance nearly as long as distance from cloaca to tip of snout; free portion of tail spine, when fully developed, about 1.0–1.4 times as long as distance between outer margins of orbits, its total length from origin about 1.3–1.7 times; its maximum breadth 5.0–6.5 % as great as its total length; only one spine on specimens seen but preceded in each case by a well mended scar, suggesting that the present functional spine is a replacement; hence two may be expected on some specimens;[157] marginal teeth about 70 on specimen counted,[158] of the shape shown in Fig. 94C, so close together as to form a nearly continuous cutting edge.

Entire upper surface of disc and of tail back to spine rather closely and evenly set with small, low, blunt tubercles, quadriradiate in form, each of the basal radii branching dichotomously (Fig. 94D); most closely crowded and largest over midbelt of disc and on root of tail, smaller to minute along margins of disc and rearward along tail posterior to spine; one similar but much larger tubercle on each shoulder on small specimens, two or more on larger; pelvics smooth. Lower surface of disc perfectly smooth; pelvics also smooth below; lower surface of tail smooth below anterior to tip of spine but sparsely and irregularly set thence rearward with minute quadriradiate tubercles or prickles,[159] some blunt but others more thorn-like.

Snout in front of orbits about 1.0–1.3 times as long as distance between outer margins of orbits, its length in front of mouth about 2.0–2.6 times as great as distance between exposed nostrils and 0.8–1.1 times as great as distance between inner ends of first gill openings. Orbit about 46 % as long as distance between orbits in small specimens but 27 % on the large one examined, and about 52–60 % as long as spiracle. Distance between inner ends of first gill openings about 2.5–2.8 times as long as distance between exposed nostrils; distance between inner ends of fifth gills about 70–80 % as long as that between first pair. Posterior margin of nasal curtain nearly

156. The anterior parts of the tails of the preserved specimens we have seen show a more or less definite groove along the midline, but we suspect that this is the result of muscular contraction rather than a normal characteristic of this species.

157. Two spines have been recorded for *H. pacifica*, a close ally. See Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 263).

158. Extreme tip broken off.

159. One of the smaller specimens studied by us has only a few of these scattered here and there on the posterior part of the tail, though it is in good condition otherwise.

straight across, its free edge deeply fringed, the individual marginal lobelets simple, bifid, or trifid; the median lobelet sometimes considerably the largest. Mouth moderately arched, the lower jaw slightly indented centrally. A deep furrow extending rearward from outer part of nostril and from corner of mouth, the skin much wrinkled and corrugated also over a zone of considerable breadth posterior to lower jaw, thus

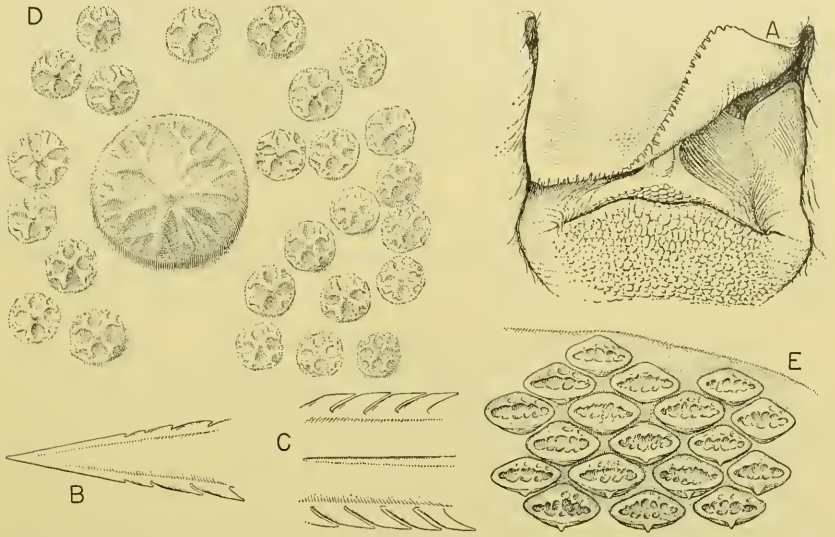

FIGURE 94. *Himantura schmardae*. *A* Nostril and mouth of male, 563 mm wide, from Toro Point, Panama Canal Zone (U. S. Nat. Mus., No. 86071), with nasal curtain rolled forward, about 0.9×. *B* Tip, and *C* Middle part of tail spine of male, 248 mm wide, from Atlantic Panama (U. S. Nat. Mus., No. 128388), about 5.5×. *D* Small tubercles and large, from shoulder of same, about 5.5×. *E* Upper teeth of another male from the West Indies (U. S. Nat. Mus., No. 33719), about 12×.

allowing a wide gape. Floor of mouth with five papillae, a blunt pair near midline alternating with three much more slender.

Teeth $\frac{28-36}{30-38}$; close-set in quincunx; oval to elliptical, their long axes parallel to jaw, the functional surface with broad furrow from side to side, irregularly scalloped in contour.

Pelvics with nearly straight anterior margins, weakly convex posterior margins and narrowly rounded corners; their rear limits posterior to rear limits of pectorals by a distance about half as great as distance between eyes; anterior margin of pelvic about 80 % as long as distance from its own origin to rear tip of pelvic. Claspers of mature males not yet studied.

Color. Uniform dark brown, sooty olive, or sepia above, the edges of the disc

darker; tail sooty or blackish posteriorly; lower surfaces of disc and pelvics yellowish or cream-white, or variously spotted with olive, yellow brown and white, conspicuously margined (at least on some specimens) with dark sooty olive or dusky. Lower surface of tail olive or brown anterior to spine, grading posteriorly into sooty or almost black. Teeth a little darker than lower surface of disc on specimens seen, sometimes considerably so.

Relationship to Extralimital Species. *H. schmardae* is most closely related to *H. pacifica* (Beebe and Tee-Van) 1941[160] from the Pacific Coast of Costa Rica, which it resembles in shape of disc, in the quadriradiate conformation of the tubercles with dichotomously branching ridges, in the distribution of these tubercles, and in the location of the tail spine (or spines) far rearward on the tail. But the two forms differ sufficiently, as tabulated below, to be classed as distinct species.

	H. schmardae	*H. pacifica*
Spiracle	1.7 –2 times as long as eye	3 times as long as eye
Longest gill opening	0.75–1 times as long as eye	2 times as long as eye
Scapular tubercles	Conspicuous	Inconspicuous

Developmental Stages. Embryos of this species have not been seen.

Size. Evidently this is one of the larger members of its family, for the tips of the claspers in a male 563 mm broad still fall some 20 mm short of the posterior margins of the pelvics, but the size reached at maturity has not been learned. A female about four feet wide from Matanzas, Cuba, is the largest recorded.[161]

Habits. Nothing whatever is known of the habits of *H. schmardae* beyond what applies to all the long-tailed Sting Rays.

Relation to Man. In the vicinity of Carman, Mexico, the dried skins of this species (the upper surface of disc and tail as far as the spine) are used as an abrasive, especially for polishing woodwork.[162]

Range. *H. schmardae* has been recorded only from: Dutch Guiana (Surinam); Trinidad; the coast of Panama on the Caribbean side, including the entrance to the Canal; Jamaica; the north and south coasts of Cuba; and from the Gulf of Campeche, Mexico. But it is more plentiful in tropical West Atlantic waters than the paucity of published records would indicate, for many have been taken in recent years near Matanzas, Cuba, and we are informed that it is quite commonly caught and seen in shallow places along the southern Cuban Coast and along the Cays off the north coast.[163]

Synonyms and References:

Trygon schmardae Werner, Zool. Jb., Syst. Abt. *21*, 1904: 298 (descr., Jamaica); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range).

160. Zoologica N. Y., *26*, 1941: 262.
161. Howell-Rivero, Proc. Boston Soc. nat. Hist., *41*, 1936: 49, as *Pastinachus torrei*.
162. Communication from Frank J. Mather III.
163. Personal communication from Luis Howell-Rivero (as *Pastinachus torrei*).

Dasybatus (*Pastinachus*) *schmardae* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 386 (descr., from Werner, 1904, Jamaica).

Dasybatus (*Pastinachus*) *torrei* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 386 (descr., cf. other species; Cuba).

Dasybatus torrei Garman, Mem. Soc. cubana Hist. nat., *2*, 1916: 178 (Spanish transl. from Garman 1913).

Dasybatus schmardae Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 81 (descr., color, size; Toro Point and Mindi Cut, Panama Canal Zone).

Pastinachus torrei Devincenzi, Rev. chil. Hist. Nat., *29*, 1925: 173 (listed, Cuba, by ref. to Garman, 1913); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (listed, W. Indies); Howell-Rivero, Proc. Boston Soc. nat. Hist., *41*, 1936: 49 (size, nos., Matanzas, Cuba).

Pastinachus schmardae Devincenzi, Rev. chil. Hist. Nat., *29*, 1925: 173 (listed, Jamaica by ref. to Werner, 1904); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 28 (listed, W. Indies).

Dasyatis schmardae Fowler, Proc. Acad. nat. Sci. Philad., *83*, 1931: 391 (color, Trinidad); Beebe and Tee-Van, Zoologica N.Y., *26*, 1941: 263 (cf. *H. pacifica* [Beebe and Tee-Van] 1941); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Jamaica; Panama); Boeseman, Zoöl. Meded., *30* (2), 1948: 32 (notes, pelvis, Surinam [Dutch Guiana]).

Probable References:

Trygon species dubia—Lesbia, No. 319, Poey, Repert. Fisico-Nat. Cuba, *2*, 1868: 457 (ident. probable because of roughness of skin, Cuba).

Raja, No. 316, Poey, Enumerat. Pisc. Cubens., 1875–1876: 205; An. Soc. esp. Hist. Nat., *4*, 1876: 205 (same as *Trygon* sp. dubia, Poey 1868).

Family GYMNURIDAE

Butterfly Rays

Characters. Front of cranium straight or weakly convex. Pelvis strongly arched forward but without distinct median process. Surfaces of gill arches smooth inward from gill filaments. Disc much broader relatively (at least 1.6 times as broad as long) and tail from cloaca relatively much shorter than in Dasyatidae (about 20–25 % as long as breadth of disc and shorter than body). Saw-edged tail spine (or spines) in some species but not in others. Some members of family with a small dorsal fin near midlength of tail. Some with a slender tentacle-like lobe on inner posterior margin of each spiracle. Transverse curtain on roof of mouth smooth-edged; no papillae on floor of mouth. Skin, apart from tail spine, naked in most but described as more or less rough on large specimens of *G. altavela* (p. 399). Characters otherwise as in Dasyatidae.

Remarks. The Butterfly Rays are so closely allied to the dasyatid Rays that they have been united commonly with the latter (and with the urolophids) in a single family.[1] But the species in question, though few in number, resemble one another so closely and they differ so widely from all the typical dasyatids in shortness of tail, shape of disc, lack of papillae on the floor of the mouth, and in having the transverse curtain on the roof of the mouth smooth-edged, that it seems preferable to group them in a separate family.

Size. The members of the family, when mature, range in breadth up to six or seven feet and perhaps grow even larger.

1. By Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 363), for example, and latterly by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 396).

Developmental Stages. The Butterfly Rays are ovoviviparous; for a further account of Development, see p. 397.

Habits. Their method of swimming, their habits, and their diet are essentially similar to those of the long-tailed Sting Rays (Dasyatidae), but little detail is known of their way of life.

Relation to Man. None are of any commercial importance anywhere. Obviously, such of them as lack a tail spine are perfectly harmless. Even those that are armed with a spine (or spines) are much less dangerous than are the long-tailed Rays, their tails being much smaller and hence less effective as weapons.

Range. Cosmopolitan in tropical to warm-temperate latitudes, in shallow coastal waters, including estuaries and river mouths.

Genera. The known species of the family fall into two groups, according to whether or not a dorsal fin is present. While the demarcation between the two may not be as sharp as the taxonomist might wish, we follow Garman[2] in recognizing two genera, *Aetoplatea* (without fin) and *Gymnura* (with fin).

Key to Genera

1a. A small but distinct dorsal fin near midlength of tail.
Aetoplatea Müller and Henle 1841.
South Africa, Red Sea, Indian Ocean, East Indies.

1b. No dorsal fin; at most a low longitudinal keel on upper surface of tail.
Gymnura van Hasselt 1823,[3] p. 396.

Genus *Gymnura* van Hasselt 1823

Gymnura van Hasselt, Allg. Konst. en Letterbode Haarlem, 1823: 316; Bull. Univ. Sci. Nat., *2*, 1824: 90; type species, *Raja micrura* Bloch and Schneider 1801; Surinam (Dutch Guiana).[4]

Generic Synonyms:

Raja (in part) Linnaeus, Syst. Nat., *1*, 1758: 232; for *R. altavela* Linnaeus.

Trygonobatus (in part) Blainville, Bull. Soc. philom. Paris, 1816: 112; for *T. altavelus* and *T. microurus* Blainville, which no doubt equal *Raja altavela* Linnaeus 1758 and *Raja micrura* Bloch and Schneider 1801.

Trygon (in part) Cuvier, Règne Anim., 2nd ed., *2*, 1829: 400, footnote; for *T. kunsua* Cuvier (based on the Tenkee Kunsul of Russell, Fish. Coromandel, *1*, 1803: 4, pl. 6); *Raja micrura* Bloch and Schneider 1801 and *Raja maclura* Lesueur 1817 also included.

2. Mem. Harv. Mus. comp. Zool., *36*, 1913: 373, 411, 412. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 450) reduces *Aetoplatea* and *Pteroplatea* to subgeneric rank under *Gymnura*.
3. The generic name *Gymnura* was published first by van Hasselt (Allg. Konst. en Letterbode Haarlem, 1823: 316 [not seen]; Bull. Univ. Sci. Nat., *2*, 1824: 90) from a manuscript by Kuhl. Müller and Henle later (S.B. Akad. Wiss. Berl., 1837: 117) used *Gymnura* for another genus of Rays, but these authors subsequently recognized that it was preoccupied (Arch. Naturg., *3*, 1837: 437); they therefore proposed *Urogymnus* as a substitute for their *Gymnura*. *Gymnura* was revived for the Butterfly Rays by Rey (Fauna Iberica, Peces, *1*, 1928: 635, and footnote) and by Fowler (Proc. Acad. nat. Sci. Philad., *85*, 1934: 241). It antedates and therefore supersedes *Pteroplatea* Müller and Henle 1841.
4. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 355) characterizes the locality as "likely erroneous" but without further comment.

Pteroplatea Müller and Henle, S.B. Akad. Wiss. Berl., 1837: 117; no species named; Plagiost., 1841: 168; type species *Raja altavela* Linnaeus 1758, designated by Jordan (Genera Fish., *2*, 1919: 193).

Pastinaca (in part) DeKay, Zool. N.Y., 4, 1842: 375; for *Raja maclura* Lesueur 1817.

Dasyatis Gray, List Fish. Brit. Mus., 1, 1851: 121; type species, *D. altavela* Gray, equals *Raja altavela* Linnaeus 1758.[5]

Ceratoptera Day, Fish. India, *1* (4), 1878: 745, fig. not numbered; for *C. ehrenbergii* Day (not Müller and Henle 1841), a monstrosity of *Gymnura*, probably *G. poecilura* (Shaw) 1804.[6]

Astrape (in part) Day, Fish. India, Suppl., 1888: 812; substituted for *Ceratoptera* Day 1878 on the incorrect supposition that the latter was a monstrosity of *Astrape dipterygia* Müller and Henle 1841, one of the Torpedo Rays.

Pteroplataea Alcock, Ann. Mag. nat. Hist., (6) *9*, 1892: 419; emended spelling for *Pteroplatea* Müller and Henle 1837, 1841.

Planerocephalus Grazianow, Zool. Anz., *30*, 1906: 400, 403; new name to replace *Ceratoptera* Day 1878; see above.

Phanerocephalus Grazianow, Zool. Anz., *30*, 1906: 404; emended spelling for *Planerocephalus* Grazianow; type species, *P. ellioti* Grazianow. India.

Not *Dasyatis* Rafinesque, Carratt. Gen. Spec. Sicil., 1810: 16; see p. 340.

Not *Gymnura* Müller and Henle, S. B. Akad. Wiss. Berl., 1837: 117; see p. 396, ftn. 3.

Not *Ceratoptera* Müller and Henle, S.B. Akad. Wiss. Berl., 1837: 118; Plagiost., 1841: 186; equals *Manta* Bancroft 1828–29, see p. 501.

Generic Characters. No dorsal fin. Characters otherwise those of the family.

Developmental Stages.[7] While both reproductive organs are functional as a rule, the left ovary is usually better developed and has the larger number of eggs. Instances have been recorded in which the left ovary alone contained eggs. Ordinarily one embryo develops in each oviduct, but occasionally two or three, and at least one case of polyembryony (two yolks within a single shell) has been observed.[8] Before the embryos are born, ovarian eggs that presage the next generation have been recorded as reaching a diameter of 5 to 10 mm. The length of the period of gestation is not known. During the early stages of embryonic development the egg is enclosed in a thin straw-colored membrane that is more or less folded or plaited at the ends; the embryo is set free from this into the uterus while it still has external gill filaments and yolk sac. The young, after liberation into the uterus, are nourished partly by the contents of the yolk sac but largely by the fluid secreted by the glandular villi with which the inner uterine walls of the mother are densely clothed. Elongated clumps of these villi extend into the spiracles of the embryo, which is evidence that it takes in the "milk" via the spiracular openings; perhaps it also takes the "milk" through the mouth and by absorbing it in early stages through its free gill filaments.[9] Advanced embryos,

5. Gray characterized his *Dasyatis* as having a disc nearly, or more than twice, as broad as long and the tail mostly shorter than the body; species included were *altavela, canariensis, micrura* and *maclura*.

6. This was a monstrosity of the same sort that has been reported for various Skates and Rays in which the anterior parts of the pectorals fail to unite with the sides of the head, hence have the form of narrow secondary lobes directed forward.

7. Knowledge of the developmental stages of this genus is due to observations by Alcock and Wood-Mason (Proc. roy. Soc. Lond., *49*, 1891: 364; *50*, 1891: 203); by Gudger (Science, N. S. *33*, 1911: 943; Proc. biol. Soc. Wash., *25*, 1912: 149; Proc. biol. Soc. Wash., *26*, 1913: 100) as *Pteroplatea maclura*; and by Radcliffe (Bull. U. S. Bur. Fish., *34*, 1913: 277).

8. By Gudger (Proc. biol. Soc. Wash., *26*, 1913: 100, as *Pteroplatea maclura*), who also lists references to polyembryony in other elasmobranchs.

9. Knowledge of the relationship between mother and embryo in *Gymnura* and of the embryonic nutrition is due

when taken from the mother, have been seen to regurgitate what appears to be this same milky substance. The embryos lie in the uterus with one wing of the disc rolled around the other ventrally and with the tip of the snout folded inward. The young are born in this condition, unfolding when they emerge from the mother. When there are two (or more) embryos in the uterus, one is rolled up around the other, head to head, in such a way that the spiracles of the inner member of the pair are exposed for the reception of the uterine villi. In one pair of embryos so entwined, one of the spiracles of the inner embryo was entirely covered over and very small, its other spiracle exposed and much larger.[10]

The tail of the embryo is nearly as long as the body, its posterior portion expanded into a broad fin. But relatively it is no longer in the young Ray at birth than in the adult, nor is it more distinctly finned.

Range. Rays of this genus occur widely in shoal inshore waters in the tropical and warm-temperate belts of all oceans; definite records are from: the Red Sea; the coasts and island groups of the Indian Ocean southward on the African side to Agulhas Bank; the Malayan region; southeastern Asia north to Japan; Australia; Polynesia; the west coast of America from southern California to Peru; in the western Atlantic from the estuary of the Rio de la Plata to the mid-Atlantic United States, occasionally to southern New England; and from tropical West Africa to the Mediterranean, Canaries, Madeira, and Portugal in the east.

Species. Recent surveys of the genus recognize about 10 or 11 species from various parts of the world. But we think it is likely that critical comparison of specimens from different regions will result in some reduction in the number of separable forms. Two easily recognizable species, perhaps a third and possibly a fourth, occur in the tropical to warm-temperate belt of the Atlantic. One of these, *G. micrura* (Bloch and Schneider) 1801, confined to the western Atlantic so far as is known, is set apart from the others in that it has no tail spine, while the margins of its spiracles are without tentacle-like structures (for discussion, see p. 403). A second species, *G. altavela* (Linnaeus) 1758, is equally well characterized by the possession of both tail spine and spiracular tentacles. A third, *G. hirundo* (Lowe) 1843, from Madeira, has been described as differing from *G. altavela* in lacking spiracular tentacles, and from *G. micrura* in that its tail is rounded rather than keeled above and that it is armed with a spine.[11] So far as we can learn, however, there has been only one account of it since it was originally described and that was of a specimen without locality.[12] It is not mentioned in recent surveys of the fishes of Portugal, of Spain, or of West Africa.[13] However, two specimens that agreed with *G. hirundo* in having a tail spine but lacking spiracular tentacles have been

chiefly to: Alcock and Wood-Mason (Proc. roy. Soc. Lond., *49*, 1891: 364; *50*, 1891: 203); Gudger (Proc. biol. Soc. Wash., *25*, 1912: 148; *26*, 1913: 100), and Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: 277).

10. Alcock and Wood-Mason, Proc. roy. Soc. Lond., *50*, 1891: 203.
11. Lowe, Proc. zool. Soc. Lond., 1843: 94.
12. Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 100, pl. 43, fig. 1.
13. Nobre, Fauna Marinha Port. Vert., *1*, 1935; Rey, Fauna Iberica, Peces, *1*, 1928; Fowler, Bull. Amer. Mus. nat. Hist., 70 (1), 1936.

recorded from southern Brazil.[14] From this it appears that *G. hirundo* is probably a valid species, for which watch should be kept among any collections of *Gymnura* from either side of the tropical-subtropical Atlantic. However, it is probable that the union of the West African *G. vaillanti* Rochebrune 1880[15] with *G. altavela* by various authors is correct, for the chief character (tricuspid teeth) that was supposed by its author to set it apart now proves to be less significant than might have been expected (see discussion, p. 403, footnote 23).[16]

Key to North Atlantic, Western South Atlantic and Tropical West African Species

1 a. Tail armed with a serrate spine or spines.

2 a. Inner posterior margin of spiracle with a slender tentacle-like structure. *altavela* (Linnaeus) 1758 (including *vaillanti* Rochebrune 1880), p. 399.

2 b. Inner posterior margin of spiracle without tentacle-like structure. *hirundo* Lowe 1843.
Madeira and perhaps southern Brazil.[17]

1 b. Tail without serrate spine or spines. *micrura* (Bloch and Schneider) 1801, p. 408.

Gymnura altavela (Linnaeus) 1758

Figures 95, 96

Study Material. Eight specimens, male and female, 392 to 1,208 mm wide, from: Rio de Janeiro, Brazil (five specimens); Barnegat, New Jersey; Point Judith, Rhode Island; and Woods Hole, Massachusetts; in Harvard Museum of Comparative Zoology and the U. S. National Museum; also photographs of one six feet wide from Delaware Bay, New Jersey; and the tail of one taken off Cape Hatteras by Albatross III, January 1950, at 30 fathoms.

Distinctive Characters. A well developed tail spine (or spines) at all stages of growth from embryo to mature and a slender tentacular structure on the inner posterior margin of each spiracle are characters that mark off *G. altavela* from *G. micrura*, the only other species of the genus that has been reported in the western North Atlantic. It is separated further from *G. micrura* by its relatively broader disc with somewhat different anterior contour (cf. Fig. 95 with 97) and by its shorter snout relative to the distance

14. By von Ihering (Rev. Mus. paul., *2*, 1897: 36) and by Ribeiro (Arch. Mus. nac. Rio de J., *14*, 1907: 182; Fauna brasil., Peixes, *2* [1] Fasc. 1, 1923: 38), both as *Pteroplatea maclura*.

15. Bull. Soc. philom. Paris., (7) *4*, 1880: 159; Act. Soc. linn. Bordeaux, *36* (Ser. 4, *6*), 1882: 54, pl. 2; Faune Senegambie, Poiss., 1883–1885: 34, pl. 2, figs. 1–3.

16. Furthermore, the tail of *G. vaillanti* is described and pictured as rounded above, not ridged or keeled as it is in typical *altavela*. But the discontinuity in this respect does not appear to us sharp enough to warrant retention of *vaillanti* as a separate species.

17. See p. 398.

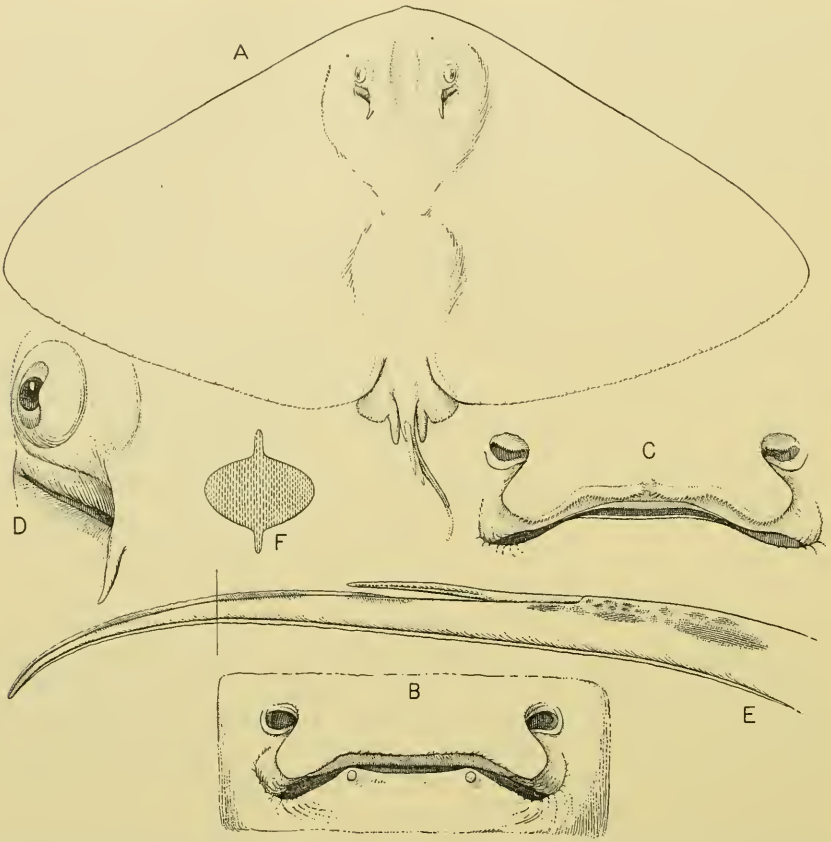

FIGURE 95. *Gymnura altavela*. *A* Male, 1,208 mm wide, from Woods Hole, Massachusetts (U. S. Nat. Mus., No. 85956). *B* Nostrils, nasal curtain, and mouth of same, about 0.5×. *C* Nostrils, nasal curtain, and mouth of male, 473 mm wide, from Barnegat, New Jersey (U. S. Nat. Mus., No. 104909), about 1.4×. *D* Eye and spiracle of same, about 3.4×. *E* Side view of tail of same, about 1.4×. *F* Cross section of tail of same at point marked by the cross line on *E*, about 5.5×.

between the gill openings. The keeled shape of the upper surface of its tail and the presence of spiracular tentacles are the chief characters that separate *G. altavela* from the somewhat problematical *G. hirundo*, which is known only from Madeira, unless, indeed, certain Brazilian specimens, reported as *G. maclura*, actually were *G. hirundo* (see discussion, p. 398).

Description. Proportional dimensions in per cent of extreme breadth of disc. Male,

473 mm wide, from Barnegat, New Jersey (U. S. Nat Mus., No. 104909). Male, 1,208 mm wide, from Woods Hole, Massachusetts (U. S. Nat. Mus., No. 85956).

Disc: length 49.3, 49.5.

Snout length: in front of orbits 7.6, 7.0; in front of mouth 10.1, 9.1.

Orbits: horizontal diameter 3.2, 2.0; distance between 7.4, 7.7.[18]

Spiracles: length 3.8, 3.8; distance between 8.9, 8.7.

Mouth: breadth 9.1, 9.4.

Exposed nostrils: distance between inner ends 6.6, 7.0.

Gill openings: lengths, 1st 2.2, 2.3; 3rd 2.2, 2.2; 5th 1.2, 1.2; distance between inner ends, 1st 17.5, 16.0; 5th 11.8, 11.7.

Pelvics: anterior margin 7.2, 8.1.

Distance: from tip of snout to center of cloaca 44.2, 45.5; from center of cloaca to origin of caudal spine 9.1, 8.0.

Disc about twice as broad as long or a little more (about 2.0–2.1 times), its anterior angle (tip of snout to level of anterior margins of orbits) about 135° in specimens measured, thus somewhat more obtuse than in *G. micrura* (p. 408); snout with blunted tip, projecting slightly from the general anterior contour; anterior margins of disc slightly sinuous in large specimens and rather more so in small ones (much as in *G. micrura*), weakly to moderately convex a little anterior to level of eyes, slightly concave at level of eyes to spiracles, and increasingly convex toward outer corners, the latter moderately rounded or more abruptly so; posterior margins weakly and almost evenly convex or nearly straight, and slightly scalloped, corresponding to the supporting radials; posterior corners broadly rounded and continuous with the strongly convex and short inner margins. Axis of greatest breadth about 58–65 % of distance rearward from tip of snout toward rear limits of disc. Tail from center of cloaca about half (50–52 %) as long as distance from center of cloaca to snout and a little less than 1/4 (22–23 %) as long as width of disc; a low ridge on both upper and lower surfaces of tail extending to tip, the upper ridge from a short distance posterior to rear point of emergence of spine, the lower ridge from about the level of rear corners of pelvics.

One or two large saw-edged tail spines a little anterior to midpoint of tail, directed rearward and rising only a little above dorsal surface of tail; spines with a median groove above and a wider channel on either side below, much as in the Dasyatidae, except that the spines are wider relative to their length; the lateral teeth strongly recurved, their outer cutting edges arcuate. If there are two tail spines, the larger is the more recently formed in some specimens (as indicated by relative stages in development) but perhaps not in all.[19] The spine, on first emerging from the skin, consists of a spear-like point alone, the lateral teeth forming successively as the spine increases in length, the number of teeth increasing from 17–18 on small specimens (450–550 mm broad) to 28 on

18. Distance between eyes 9.3, 9.6.

19. On a specimen 1,208 mm wide, the two spines are of about equal length (67–68 mm), hence the order in which they were produced is not clear. Nor is it clear whether some specimens produce two spines and others only one, or whether those with only a single spine have lost one member of the pair.

each side of the posterior spine and 43 (those toward base minute) on each side of the anterior spine on one 1,208 mm wide; it is likely that the teeth are still more numerous on adults.

Skin, apart from tail spines, perfectly smooth on small and medium-sized specimens, but described as more or less roughened on large adults.[20]

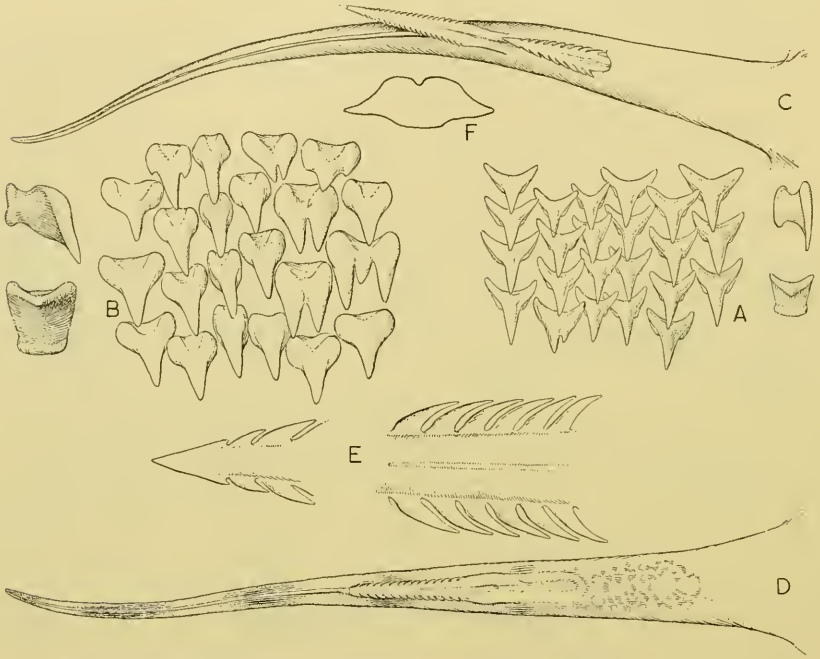

FIGURE 96. *Gymnura altavela*. *A* Upper teeth from near center of jaw of female, 549 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 533), about 16×. *B* Upper teeth from near center of jaw of immature male, 1,208 mm broad, from Woods Hole, Massachusetts (U. S. Nat. Mus., No. 85956), about 14×. *C* Upper surface of tail of female, 549 mm wide, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 533), and *D* Same of male, 473 mm wide, from Barnegat, New Jersey (U. S. Nat. Mus., No. 104909) to show variation in number of tail spines, about 1.4×. *E* Tip and middle part of tail spine of male, 1,208 mm wide, from Woods Hole, Massachusetts (U. S. Nat. Mus., No. 85956), and *F* Cross section of same, about 3.7×.

Snout anterior to orbits a little more than half (55–57 %) as long as distance between outer margins of orbits (thus considerably shorter relatively than in *G. micrura*, where this proportion usually ranges between 70 and 90 %); its length in front of

20. Described as "shagreened" by Lesueur (J. Acad. nat. Sci. Philad., *1*, 1817: 42) and as "rugueux" on the central part of the disc by Rochebrune (Act. Soc. linn. Bordeaux, [4] *6*, 1882: 55) for his *G. vaillanti*, which is probably not distinguishable from *altavela* (see discussion, p. 399).

mouth about 1.3–1.5 times as great as distance between exposed nostrils. Orbit about 39–43 % as long as distance between orbits; about $^2/_3$ as long as spiracle on young specimens, but only about half as long as spiracle at maturity. Inner posterior margin of spiracle with a slender tentacular structure directed outward and rearward, about 2.3 times as long as horizontal diameter of eye on small specimens but only about half as long as eye on larger ones. Anterior margins of gill openings a double curve, much as in *G. micrura;* the first to third (longest) about $^2/_3$ as long as orbit on small specimen (473 mm wide) and about equal to orbit on one of 1,208 mm, the fifth only about 50–60 % as long as first to third gill openings; distance between inner ends of first pair about 2.3–2.7 times as great as distance between exposed nostrils; distance between inner ends of fifth pair about 68–73 % as great as distance between first pair. Posterior outline of nasal curtain weakly concave along median sector, the outer corners projecting rearward in rounded outlines,[21] the free edge of nasal curtain finely but irregularly fringed on some small specimens, except for a narrow gap in midline, but nearly smooth on others and on larger ones. Lower jaw moderately arched anteriorly except along midsector where it is straight or even weakly concave, the points of alteration of curvature marked outwardly on large specimens by more or less prominent rounded knobs caused by corresponding swellings of the mandibular cartilage.[22]

Teeth $\frac{98}{78}$ in a specimen 473 mm broad but increasing in number to about $\frac{138}{110}$ in a 1,208 mm specimen, perhaps to a still larger number in very large ones; close-set, in quincunx or transverse series in both sexes; the bases relatively shorter anteroposteriorly and broader transversely on smaller than on larger specimens; usually one moderately high conical cusp, as sharp on small specimens as on larger males, occasionally two or three cusps (Fig. 96);[23] 10–12 rows in function simultaneously in each jaw, perhaps more on largest examples; upper dental band occupying about 70 % of breadth of jaw, the lower a little less.

Pelvics brush-shaped, much as in *G. micrura*, extending rearward beyond rear limits of pectorals for a distance about as great as length of spiracle; outer and inner margins nearly straight, posterior margin weakly convex; corners moderately rounded. Claspers of mature males not yet studied.

Color. Disc usually dark brown above, with grayish or reddish cast, or coffee brown, shading to cinnamon at margins; variously marked with small darker dots or dark or pale spots or blotches of indefinite outline, often in a marbled pattern; sometimes with pale-rimmed ocellar spots; upper surface of tail of same ground color as disc, marked on small specimens with pale crossbars (extensions of the pale color of the lower surface), or with dark and pale bars, which are mostly lost with growth.[24]

21. This is one of the minor characters in which *G. altavela* differs from *G. micrura* (cf. Fig. 95 B with 97 A).
22. These swellings, in the form of "hard knoblike denticles", are pictured as sharp-pointed on *G. crooki* of Japan (Fowler, Bull. U. S. nat. Mus., 100 [13], 1941: 455, fig. 12).
23. The presence of occasional teeth with two cusps on one small specimen, and of a few with three cusps on a male of 1,208 mm (about 4 ft.) is evidence that the tricuspid teeth described and pictured by Rochebrune (Act. Soc. linn. Bordeaux, [4] 6, 1882: 54, pl. 2, fig. 3) for his *vaillanti* cannot serve as a basis for specific separation.
24. The tail shows these crossbars on a specimen 473 mm broad from Barnegat, New Jersey, and it is similarly described

Lower surface of disc and of pelvics white, of brownish, rosy, or rusty cast, with narrow sooty or rusty-brown edgings; tail white, or rosy white below, its anterior part more or less clouded in some cases by expansions of the dark color of the upper surface.

The variability of coloration in *G. altavela* is illustrated by the fact that a specimen from Newport, Rhode Island, almost certainly of this species, was greenish-blue above, marked with dark vermiculations and larger pale red spots, whereas large West African Butterfly Rays, probably of this species,[25] have been described as yellowish above, finely marbled with green markings; the pelvics were described as wine red, the tail as brown above, its spine as rosy with blackish margins and teeth, and the lower surface as rosy white.

Comparison with Indo-Pacific Species. The only Indo-Pacific Butterfly Ray with which *G. altavela* agrees in the presence of spiracular tentacles is the *tentaculata* of Müller and Henle 1841, which falls in the genus *Aetoplatea*, since its tail bears a dorsal fin. See p. 398 for comparison with other Atlantic species.

Size. Fully formed embryos are reported as 15–17 1/2 inches wide (382–444 mm) and hence much larger than *G. micrura* at birth.[26]

The size at which males mature sexually, and probably females as well, appears to vary widely from specimen to specimen. Although the claspers of a male 1,208 mm wide project beyond the pelvics for a distance equal to only about 1/3 of the length of the outer margins of the pelvic fins, and although the state of development of the tips suggests that this individual probably would not have become sexually active until it reached a breadth of about 1,300 mm (51 in.), a mature male only 1,068 mm broad (42 in.) has been recorded from Madeira.[27]

A female 6 feet 10 inches wide (2,082 mm)[28] from Cape Lookout, North Carolina appears to be the largest western Atlantic specimen reported so far that can be referred without reservation to *G. altavela*. But it may grow to twice that size, for its West African representative reputedly attains a breadth of more than four meters (about 13 ft.).[29]

Developmental Stages. We know only that embryos nearly ready for birth are already armed with tail spines[30] and that a female taken at Cape Lookout, North Carolina, contained four young.

Habits. Although the Giant Butterfly Ray has been known to science since 1616[31]

by Müller and Henle (Plagiost., 1841: 168) for a specimen 15 1/2 inches wide. Unfortunately, the tail of the largest specimen we have seen is damaged. No mention or indication of tail-bars is given in any of the accounts or illustrations of fully grown specimens with which we are acquainted.

25. Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 54, pl. 2, fig. 1, as *Pteroplatea vaillanti*.
26. Coles (Proc. biol. Soc. Wash., *28*, 1915: 93). No information is available as to whether specimens 392 to 550 mm broad from New Jersey and Brazil (examined by us) were late embryos taken from their mothers or were young free-living individuals.
27. Günther (Cat. Fish. Brit. Mus., *8*, 1870: 486); identity established by presence of spiracular tentacles.
28. Nichols, Bull. Amer. Mus. nat. Hist., *33*, 1914: 537; Coles, Proc. biol. Soc. Wash., *28*, 1915: 93.
29. *G. vaillanti* Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 54; probably identical with *G. altavela*; see discussion p. 399.
30. Coles, Proc. biol. Soc. Wash., *28*, 1915: 93.
31. It is the Pastinaca marina altera of Fabius Columna (Aquitilium observ., *C* 2, 1616: 4, pl. 2) and of Willughby (Hist. Pisc., *4*, 1686: 65, pl. 101, fig. 3).

and occurs in seas (including the Mediterranean) where the fish fauna has been studied at many hands, all that is known of its manner of life is that it is most often encountered in shoal water. But it may not be limited to the immediate vicinity of the coast, for one has been taken 20 miles at sea off Cape Hatteras (see Study Material, p. 399) at a depth of 30 fathoms by Albatross III, while another Butterfly Ray, probably of this species, has been reported off tropical West Africa from a depth of eight fathoms.[32] It has been described as grunting loudly with the sudden expulsion of air from its mouth while lying on deck after capture.[33] However, it is not known whether this Ray, or any other, normally produces noises while in the water.

Numerical Abundance. All of the published reports of *G. altavela* in the western Atlantic have been based either on single specimens or on two or three at most, except for a fisherman's report that suggests the visit of a school to the North Carolina Coast in May 1914.[34] Thus it is doubtful whether any considerable population of *G. altavela* exists anywhere off the North or South American coasts. This contrasts sharply with its reported abundance on the African Coast in the vicinity of Cape Blanco[35] and along Senegambia, if *G. vaillanti* (Rochebrune) 1880 is actually identical with *altavela*, as seems probable (p. 399).

Range. Tropical to temperate latitudes in continental waters on both sides of the Atlantic; Portugal, the Mediterranean, Madeira, the Canaries to Cape Blanco, West Africa, and probably to Senegambia in the east; southern Massachusetts to the mouth of the Rio de la Plata in the west.

Occurrence in the Western Atlantic. The Giant Butterfly Ray was reported from Brazilian waters as *G. altavela* more than a century ago[36] and from southern New England as *maclura* a quarter of a century earlier.[37] Subsequent reports of it from the western Atlantic are equally widely separated in latitude. The additional list of positively identifiable records,[38] so far as we can learn, are as follows: two specimens from the vicinity of Montevideo; one from Brazil (locality not stated); five from Rio de Janeiro, included in our Study Material (p. 399); three from Rio Grande do Sul, Brazil, unless, indeed, these belonged to the problematical species *G. hirundo*[39] (see discussion, p. 398); a female, 6 feet 10 inches wide containing four young, taken on May 22, 1914, and two others, probably of this species because of the tail spines, seined by a local fisherman at Cape Lookout, North Carolina,[40] where a school of them may have visited the coast at the time; one taken 20 miles off Cape Hatteras in 30 fathoms by Albatross III on January 23, 1950 (see Study Material, p. 399); reports without

32. Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 55; *Pteroplatea vaillanti*, reported "par huit brasses de profondeur sur fond de vase."
33. Pappenheim, Ann. Naturh. (Mus.) Hofmus. Wien, *21*, 1906: 96.
34. Coles, Proc. biol. Soc. Wash., *28*, 1915: 93.
35. Chabanaud and Monod, Bull. Etud. Hist. Sci. Afr. Occid. Franç. (1926), 1927: 233.
36. Müller and Henle, Plagiost., 1841: 168.
37. Lesueur (J. Acad. nat. Sci. Philad., *1*, 1817: 41); Newport, Rhode Island specimen 6 feet 7 inches wide.
38. *G. altavela* has been listed also from the vicinity of Charleston, South Carolina (Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 162). However, we examined these specimens, one 185 mm wide and two unborn young of 180 and 197 mm, and found them to be *G. micrura*.
39. Von Ihering, Rev. Mus. paul., *2*, 1897: 36.
40. Coles, Proc. biol. Soc. Wash., *28*, 1915: 93.

details from Maryland and from Virginia; one six feet wide from Delaware Bay;[41] a very small one from Barnegat, New Jersey, examined by us; one 6 feet 7 inches wide from Newport, Rhode Island, which was the basis for Lesueur's (1817) species *maclura;* one four feet wide from Point Judith, Rhode Island, in our Study Material; and a male 1,208 mm from Woods Hole, Massachusetts, also included in our Study Material, the capture of which[42] has formed the basis for extending the known range of this species northward and eastward to Massachusetts. To complete the record, we should note the possibility that some of the Butterfly Rays that have been recorded from the Middle and South Atlantic coasts of the United States as *maclura*, but without any other indication as to their specific identity,[43] may have been *altavela*.

These recorded captures are so few as to raise the question whether *G. altavela* occurs regularly anywhere along the coasts of North or South America. Perhaps small local populations develop temporarily here or there, recruited by the young that are produced wherever adults occur. It is even possible that the presence of this species in the western side of the Atlantic may depend on occasional individuals that stray in the equatorial currents, north or south, from the West African side, where this Butterfly Ray appears to be much more plentiful.

Synonyms and References:

Raja altavela Linnaeus, Syst. Nat., *1*, 1758: 232 (Medit.).

Raja ţastinaca β *altavela* Linnaeus, Syst. Nat., *1*, 1766: 396 (Europe).

Raja altavela β Gmelin, Syst. Nat., *1*, 1789: 1509.

Dasyatis altavilla Rafinesque, Indice Ittiol. Sicil., 1810: 49 (listed, Sicily).

Raja maclura Lesueur, J. Acad. nat. Sci. Philad., 1, 1817: 41, pl. not numbered (descr., color, ill., size; Newport, Rhode Island).[44]

Le Pastenaque de Fabius Columna (no scientific name) Blainville, in Vieillot, Faune Franç., Poiss., 1825: 37[45] (descr.).

Trygon maclura Cuvier, Règne Anim., *2*, 1829: 400, footnote (by ref. to Lesueur, 1817); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 513 (descr., Rhode Island, by ref. to Lesueur, 1817).

Trygon altavela Bonaparte, Icon. Faun. Ital., *3*, 1835: pl. not numbered (descr., ill., Medit.); Lowe, Proc. zool. Soc. Lond., 1839: 92 (Madeira); Trans. zool. Soc. Lond., *3* (1), 1842: 20 (same as Lowe, 1839, Madeira); Vieira, Ann. Sci. nat. Porto., *4*, 1897: 142 (listed, Setubal, Portugal).

Pteroplatea altavela Müller and Henle, Plagiost., 1841: 168 (descr., meas., Medit., Atlant. O., Brazil); Bonaparte, Att. Congr. Sci. Ital. Genoa (1845), 1846: 12 extra; also, Cat. Pesc. Europ., 1846: 12 (listed); Duméril, Hist. Nat. Poiss., *1*, 1865: 611 (descr., color, spiracular tentacle mentioned, but not tail spine); Canestrini, in Cornalia et al., Fauna d'Ital., Pesci, 2, 1870: 60 (listed, Naples, Sicily, Gulf of Venice); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 486 (descr., Madeira and Brazil); Gervais and Boulart, Poiss., *2*, 1877: 246, pl. 97 (descr., color); Giglioli, Elenc. Pesc. Ital., 1880: 55 (listed); Brito-Capello, Cat. Peix. Portugal, Mem. Acad. Sci. Lisboa, *46* (1), 1881: 53 (listed, Portugal); Doderlein, Man. Ittiol. Medit., 2, 1881: 230 (descr., refs., Medit. locals.);[46] Perugia, Elenc. Pesc. Adriat., 1881: 59 (listed, Venice); Carus, Prod. Fauna Medit., *2*, 1889–1893: 518 (diagn., Medit.); Moreau, Poiss. France, Suppl., 1891: 14 (descr., color, meas., S. France); Ichthyol. Franç., 1892: 82 (not seen); Vinciguerra,

41. Reported with photographs by Harold Haskin as speared in August 1948 at Pierce's Point, Delaware Bay, in shallow water.

42. Coker, Copeia, 110, 1922: 65.

43. See list, p. 416.

44. A spiracular tentacle is neither mentioned nor pictured; probably overlooked.

45. According to Sherborne and Woodward (Ann. Mag. nat. Hist., [7] *8*, 1901: 493), the "Poissons" was published April 30, 1825.

46. See Doderlein for additional Mediterranean references not listed here.

Atti Soc. Ital. Sci. Nat. Milano, *34*, 1893: 301 (Canaries, by ref. to Valenciennes, 1843); Pappenheim, Ann. Naturh. (Mus.) Hofmus. Wien, *21*, 1906: 96 (size, tail spines, meas., teeth, color, noise emitted, Morocco); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 181, 208 (descr., refs., Brazil, by ref.); Seabra, Bull. Soc. portug. Sci. Nat., *6*, 1911: 204 (listed, Portugal); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 415, pl. 53, fig. 6, pl. 57, fig. 3, pl. 72 (descr., ills., pelvis, heart, skel.); Nichols, Bull. Amer. Mus. nat. Hist., *33*, 1914: 537 (female, 6 ft. 11 in. wide with embryos, C. Lookout, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 93 (size, embryos, probable occurr. of others, C. Lookout, N. Carolina); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 277 (same spec. as in Nichols, 1914 and Coles, 1915); Metzelaar, Trop. Atlant. Visschen, 1919: 200 (listed, C. Blanco, W. Africa); Coker, Copeia, 110, 1922: 65 (male, Woods Hole, Mass., same spec. pictured here in Fig. 95A, 95B); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 38 (same as Ribeiro, 1907); Chabanaud and Monod, Bull. Etud. Hist. Sci. Afr. Occid. Franc., 1927: 233 (nos., Port Etienne, W. Africa); Nichols and Breder, Zoologica N.Y., *9*, 1927: 27 (diagn., ill. Woods Hole, by ref. to Coker, 1922); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 37 (ill., size); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn.); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 29 (listed, trop. Atlant., N. to Medit., N. Carolina, Woods Hole); Uriarte and Mateu, Notas Inst. esp. Oceanogr., (2) *53*, 1931: 33 (listed Canaries, nos. near C. Blanco); Noronha and Sarmento, Peixes Madeira, 1934: 124 (Madeira; not seen); Nobre, Fauna Marinha Port. Vert., *1*, 1935: 487, pl. 69, fig. 212 (descr., ill., Portugal); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 131; Bull. Amer. Mus. nat. Hist., 70 (2), 1926: 1157 (descr., ill., Virginia, Maryland specs., refs. for W. Africa); White, Bull. Amer. Mus. nat. Hist., *74*, 1937: 91 (no. heart valves, after Garman 1913); Hildebrand, Copeia, 1941: 222 (listed, C. Lookout, N. Carolina); Helling, Mem. Estud. Mus. Zool. Coimbra, 149, 1943: 107 (listed, Portugal); Maul, Lista Peixes Madeira, Mus. Municipal Funchal, 1949: 140 (listed, Madeira).

Pastinaca maclura DeKay, Zool. N.Y., 4, 1842: 375, pl. 65, fig. 213 (after Lesueur, 1817).

Pteroplatea canariensis Valenciennes, in Webb and Berthelot, Hist. Nat. Canaries, *2* (2), Ichthyol., 1843: 100, pl. 23, fig. 1 (descr., ill., Canaries): Guichenot, Explor. Alger., Poiss., *5*, 1850: 137 (descr., color, Algeria); Duméril, Hist. Nat. Poiss., *1*, 1865: 611 (descr., color, Canaries).

Dasyatis canariensis Gray, List Fish. Brit. Mus., *1*, 1851: 122 (listed, Canaries).

Dasyatis altavela Gray, List Fish. Brit. Mus., *1*, 1851: 122 (listed, Medit.).

Dasyatis maclura (in part) Gray, List Fish. Brit. Mus., *1*, 1851: 123 (listed, N. Amer. by ref. to Lesueur, 1817, but also includes *Pteroplatea maclura* Müller and Henle 1841, equals *micrura* [Bloch and Schneider] 1801).

Pteroplatea valencienni Duméril, Hist. Nat. Poiss., *1*, 1865: 612 (descr., color, Brazil); Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 101, pls. 44, 45 (mucous canal system, ill. shows tail spine).

Pteroplatea altavela var. *canariensis* Doderlein, Man. Ittiol. Medit., 2, 1881: 232 (descr., refs., Canaries).

Pteroplatea maclura (in part) Tracy, 36th Rep. R. I. Comm. inl. Fish., 1906: 48 (Newport, Rhode Island by ref. to Lesueur, 1817, but refs. for lower Narragansett Bay and for Connecticut by ref. to Linsley 1844, probably were *Dasyatis centroura*; see discussion, p. 416); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 14 (Newport, Rhode Island, by ref. to Lesueur 1817, but not refs. for Connecticut; see Tracy 1906); Tracy, 40th Rep. R. I. Comm. inl. Fish., 1910: 63 (Newport, Rhode Island, and Woods Hole, but not ref. for Connecticut; see Tracy, 1906).

Pteroplatea maclura Devincenzi, Rev. chil. Hist. nat., *29*, 1925: 170 (listed, Rio de la Plata); An. Mus. Hist. nat. Montevideo, (2)*2*, 1926: 202 (descr., ident. by spiracle and tail spines, Montevideo); Devincenzi and Barattini, An. Mus. Hist. nat. Montevideo, (2) *2*, Suppl., Album Ictiol., 1926: pl. 4, fig. 3 (ill. probably of specimen descr. by Devincenzi 1926); Pozzi and Bordale, An. Soc. cient. argent., 120, 1935: 154 (listed, Lat. 35° S, probably by ref. to Devincenzi 1925, 1926).

Gymnura altavela Rey, Fauna Iberica, Peces, *1*, 1928: 636 (descr., ill., Spain and Portugal).

Probable References:

Pteroplatea vaillanti Rochebrune, Bull. Soc. philom. Paris, (7) *4*, 1880: 159; Act. Soc. linn. Bordeaux, (4) *6*, 1882: 54, pl. 2; also, Faune Senegambie, Poiss., 1883–1885: 31, pl. 2 (descr., ill. teeth, color, size, Senegambia; see discussion, p. 399); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range).

Pteroplatea micrura (in part) Fowler, Occ. Pap. Mus. Zool. Univ. Mich., 56, 1918: 16 (listed, Smiths Island, Virginia, *altavela* probably included because largest 1,320 mm wide).

Probably not *Pteroplatea maclura* von Ihering, Rev. Mus. paul., *2*, 1897: 36 (Rio Grande do Sul, Brazil, descr. with tail spines but without spiracular tentacle, hence probably *G. hirundo*; see discussion, p. 398); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 182 (same specimen as in von Ihering, 1897); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 38 (same as Ribeiro 1907).

Not *Gymnura altavela* Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 99, 161 (Charleston, S. Carolina and Beaufort, N. Carolina; embryos of *G. micrura* 180–197 mm wide, ident. by us; see p. 405, footnote 38.

Gymnura micrura (Bloch and Schneider) 1801

Lesser Butterfly Ray

Figures 97, 98

Study Material. Thirty-nine preserved specimens, up to 780 mm wide, including embryos, from: Gulf of Campeche, Mexico; Galveston, Texas; Barataria Bay and Grand Isle, Louisiana; Apalachicola, Tampa, Captiva Key, and the vicinity of Smyrna, Florida; Charleston, South Carolina; "Carteret County," Beaufort, and off Cape Lookout, North Carolina; Willoughby Point and Cape Charles, Virginia; and Woods Hole, Massachusetts; in the collections of Charleston Museum, Harvard Museum of Comparative Zoology, and U. S. National Museum; also seven from Galveston, Texas and one from Wine Island, Louisiana, in the U. S. National Museum, identified by the late S. F. Hildebrand; also several hundred Chesapeake Bay specimens up to 34 inches wide, examined by us while fresh.[47]

Distinctive Characters. The only Ray of the western North Atlantic with which this species might be confused would be the young of its larger relative *Gymnura altavela*. But it is set apart sharply from the latter by the fact that the inner posterior margin of its spiracle does not bear a tentacle-like structure nor does its tail have a spine (on this latter point, see discussion, p. 410). Also, its disc is considerably longer relative to its breadth and has a somewhat different contour (*cf.* Fig. 97A with 95A), and its snout is longer relative to the distance between the gill openings. The absence of a tail spine, combined with the fact that the upper surface of its tail is keeled, serves to separate *G. micrura* from *G. hirundo*, if, indeed, the latter is a recognizable species (see discussion, p. 398).

Description. Proportional dimensions in per cent of extreme breadth of disc. Three males, 276 to 364 mm wide, and three females, 319 to 565 mm wide, from near Smyrna, Florida and Galveston, Texas.

Disc: length, males 59.7 to 63.0, females 55.5 to 56.2.

Snout length: in front of orbits, males 11.8 to 13.2, females 8.6 to 9.1; in front of mouth, males 12.9 to 14.4, females 9.7 to 10.0.

Orbits: horizontal diameter, males 2.9, females 2.1 to 2.8; distance between, males 8.1 to 9.1, females 8.1 to 9.3.

Spiracles: length, males 2.4 to 3.7, females 2.5 to 3.5; distance between, males 8.9 to 10.3, females 8.7 to 9.6.

Mouth: breadth, males 8.9 to 9.4, females 9.2 to 9.7.

47. Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 68.

Exposed nostrils: distance between inner ends, males 6.6 to 7.3, females 6.2 to 6.6.

Gill openings: lengths, 1st, males 1.8 to 2.2, females 1.8 to 1.9; 3rd, males 1.9 to 2.2, females 1.8 to 1.9; 5th, males 1.0 to 1.2, females 0.9 to 1.2; distance between inner ends, 1st, males 15.0 to 15.9, females 15.9 to 16.6; 5th, males 10.4 to 11.4, females 11.3 to 11.6.

Pelvics: outer margin, males 8.4 to 9.1, females 7.6 to 9.4.

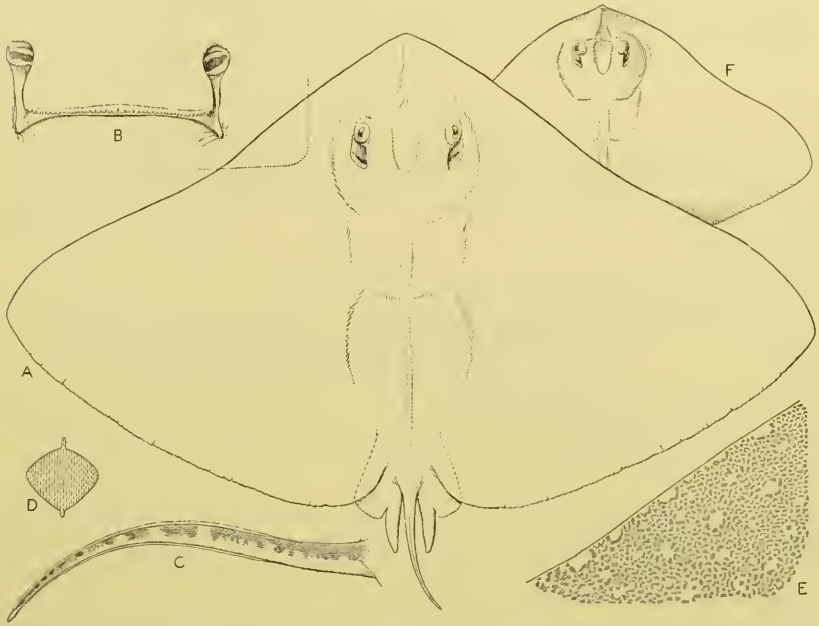

FIGURE 97. *Gymnura micrura*. *A* Male, 420 mm wide, from Beaufort, North Carolina (U. S. Nat. Mus., No. 51940). *B* Nostrils, nasal curtain, and mouth of same, about 1×. *C* Side view of tail of same to show color pattern and upper and lower tail folds, about 1×. *D* Cross section of tail at about midpoint, about 2.8×. *E* Sector from outer-anterior margin of disc to show detail of color pattern, about 1×. *F* Juvenile female, about 216 mm wide, from Apalachicola, Florida (U. S. Nat. Mus., No. 127298) to show shape of front of disc.

Distance: from tip of snout to center of cloaca, males 53.0 to 57.8, females 50.0 to 51.5; from center of cloaca to tip of tail, males 23.0 to 24.7, females 21.9 to 23.2.

Remarks. There is a considerable sexual difference in certain proportions, notably in the length of the disc, in the length of the snout in front of the orbits as well as in front of the mouth and in the distance from snout to center of cloaca.

Disc lozenge-shaped, about 1.6 to 1.7 times as broad as long in males, 1.7 to

1.8 times in females; tip of snout more or less blunted and projecting slightly from general anterior contour; anterior angle from tip of snout to level of anterior margins of orbits about 120–130° in males, 130–140° in females; anterior margins weakly convex in front of general level of eyes, slightly concave opposite level of posterior edge of spiracles, weakly convex again toward outer corners; outer corners narrowly rounded or subangular; posterior margins weakly and evenly convex, their edges finely scalloped; posterior corners broadly rounded, merging insensibly into short and moderately convex inner margin. Axis of greatest breadth about 55–60 % of distance back from tip of snout toward rear limits of disc in females, about 60–70 % in males. Tail

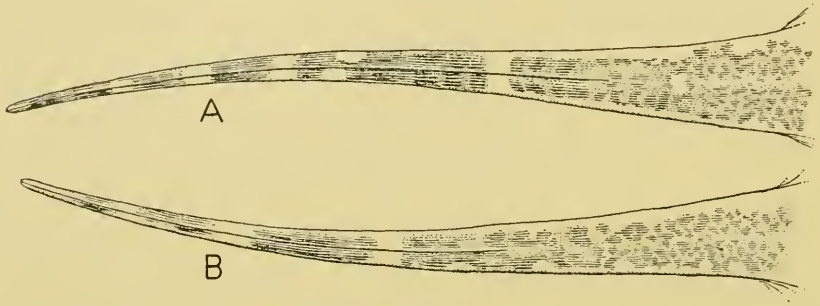

FIGURE 98. *Gymnura micrura*. *A* Dorsal view of tail of male, 420 mm wide, from Beaufort, North Carolina (U. S. Nat. Mus., No. 51940), and *B* of male, 390 mm wide, from Willoughby Point, Virginia (U. S. Nat. Mus., No. 25452) to show variations in color pattern, about 2.2×.

tapering, its length from center of cloaca 37–46 % as great as distance from center of cloaca to tip of snout and about 1/4 (22–25 %) as great as width of disc; its lower surface with a low longitudinal dermal ridge or keel, the upper surface with a similar but somewhat more prominent keel, each extending along posterior two-thirds of tail.

No tail spine at any age, this being one of the chief characteristics of the species.[48]

Snout anterior to orbits about 70–80 % as long as distance between outer margins of orbits in females, about equal to this distance in males; its length in front of mouth about 1.5–1.7 times as great as distance between exposed nostrils in females, 2.0–2.1 in males. Spiracle about as long as orbit in small specimens but up to about 1.8 times as long in large ones; its inner posterior margin perfectly smooth without trace of any tentacular structure at any stage in growth. Anterior margins of gill openings sinuous; first to third (longest) about 2/3–3/4 as long as diameter of orbit; fifth gill openings only about half as long as first to third; distance between inner ends of first pair about

48. So far as we can learn, there is no published record of the presence of a tail spine on any specimen that can be referred with certainty to *G. micrura*. It has been stated repeatedly that large specimens may have tail spines, but such reports hark back either to the original specimen of *G. maclura* (Lesueur) 1817, which appears to have been a *G. altavela* (p. 406), or refer to other specimens so large that they almost certainly belonged to that species, not to *G. micrura*.

2.2–2.6 times as great as distance between exposed nostrils; distance between inner ends of fifth pair about 70 % as great as distance between first pair. Nasal curtain reaching to upper jaw, its free posterior margin nearly straight or weakly concave; finely fringed with short irregular lobes, except for a narrow gap in the median line on some specimens. Lower jaw and lip moderately arched rearward toward corners but nearly straight along midsector.

Teeth about $\frac{60}{52}$ to $\frac{120}{106}$ on specimens counted,[49] closely crowded in transverse rows, similar in the two jaws, each tooth with one short sharp conical cusp on somewhat swollen base in both sexes; 8–9 or more rows in function simultaneously; upper dental plate occupying about 70–75 % of breadth of jaw, the lower only about 60–65 %, the outer parts of the jaws thus without teeth.

Pelvics extending rearward beyond posterior limits of pectorals for a distance about as great as length of eye; their outer and posterior margins nearly straight, the inner margin weakly convex on young of both sexes and on females to maturity; their corners abruptly rounded. Claspers of mature males slender, tapering a little to simple tips, reaching rearward about halfway along tail.

Color. Fresh-caught specimens are gray, brown, light green, or purple above, dotted and vermiculated with paler and darker; the outer anterior margins of disc frequently with roundish spots, paler or darker; the tail with three or four dark crossbars, variable in position, in breadth, and in distinctness. Lower surface white, outer margin of disc more or less conspicuously edged with grayish, with dusky, yellowish, or with salmon. This Ray has some ability to adapt its shade to that of the bottom, darkening when on a black background and fading to pale on a white ground.[50]

Comparison with Pacific and Indian Ocean Species. The specific name *micrura*, belonging properly to the smaller Butterfly Ray of the western Atlantic,[51] has been applied by many authors to an Indo-Pacific Butterfly Ray, the earliest account of which was given as *Raja poecilura* Shaw 1804.[52] However, *poecilura* differs strikingly from *micrura* of the Atlantic in its much longer tail[53] and usually in the presence of one or more tail spines.

G. micrura resembles *G. marmorata* (Cooper) 1863 from the coasts of California and Pacific Central America more closely, especially in shortness of tail, and *G. japonica* (Schlegel) 1850 of Japan (*G. bimaculata* Norman 1925 appears hardly separable from the latter). However, all of the specimens of *G. marmorata* from California that we have seen have been armed with small tail spines, corroborating published accounts,[54] while *G. japonica* is similarly described (not seen by us) as having a small tail spine.

49. The number of teeth increases with growth, there being $\frac{60}{52}$ in one 276 mm wide, $\frac{82}{66}$ in one of 364 mm, $\frac{98}{84}$ in one of 565 mm, and $\frac{120}{106}$ in one of 780 mm.
50. Mast, Bull. U. S. Bur. Fish., *34*, 1916: 181.
51. The type locality of the species was Surinam (Dutch Guiana).
52. Gen. Zool., *5*, 1804: 291, based on the Tenkee Kunsal of Russell (Fish. Coromandel, *1*, 1803: 4, pl. 6).
53. The tail of *G. poecilura* is described as varying from a little shorter to a little longer than the body. In one 290 mm wide from Ceylon, examined by us, it is a little shorter than the distance from the center of the cloaca to the mouth, and on another 380 mm wide from Penang it is about as long as the distance from the cloaca to the mouth.
54. For list of references to *G. marmorata*, see Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 264).

The Peruvian *G. afuerae* Hildebrand 1946,[55] which resembles *G. micrura* in having no tail spines or spiracular tentacles, differs from *micrura* in its smaller eyes relative to the spiracles, in the somewhat more acute anterior contour of its disc, and in the absence of a longitudinal keel on the lower side of its tail. But the relationship remains to be established between *G. micrura* of the Atlantic and the short-tailed spineless Butterfly Rays without spiracular tentacles that have been reported as *micrura* from South Africa,[56] Borneo,[57] and Australia,[58] as *australis*[59] from Australia, and as *crooki* from Japan.[60] See page 398 for comparison with other Atlantic species.

Size. The breadth of the disc at birth may be as small as six inches[61] or as great as 8–9 inches.[62] Females produce young when 25–26 inches wide,[63] and probably while smaller still, for a male only 420 mm wide (about 16½ in.) in our Study Material appears to have been nearing maturity, to judge from its claspers. A female 34 inches wide from Chesapeake Bay, measured by us, was not only the largest among many but was one of the largest ever reported that can be referred with confidence to the present species rather than to *G. altavela*.[64] Thus it seems that the maximum breadth to which this species ordinarily grows is not more than 3–4 feet. It is true that *G. micrura* has been credited repeatedly with attaining a breadth of 6–7 feet, but all reports of Butterfly Rays broader than 4–4½ feet from the western North Atlantic, under whatever name, seem to have referred to *G. altavela* rather than *G. micrura*, unless *G. hirundo* is a valid species and occurs occasionally on the coast of North America.

Developmental Stages. For an account of the developmental stages which undoubtedly apply equally to *G. micrura* and *G. altavela*, see p. 397 under the genus *Gymnura*.

Habits. The Lesser Butterfly Ray appears to prefer a sandy bottom, so much so that it is known locally in Chesapeake Bay as "Sand Skate." In the few recorded cases from Beaufort, North Carolina and the vicinity of Woods Hole, Massachusetts, its stomach has contained fragments of fish, crabs, shrimps, various bivalve mollusks (the razor clam *Solenomya* among them), and even such minute objects as copepods, and the megalops larvae of crabs. It is encountered most often in shallow water, as is illustrated in Chesapeake Bay by the frequency with which it finds its way into the pound nets.

55. Bull U. S. nat. Mus., 189, 1946: 71, 72, fig. 16.
56. Barnard, Ann. S. Afr. Mus., *21* (1), 1925: 80.
57. Vinciguerra, Ann. Mus. Stor. nat. Genoa, 50, 1926: 625.
58. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 457.
59. Ramsay and Ogilby, Proc. Linn. Soc. N. S. W., *10*, 1886: 575; Whitley, Fish. Aust., 1, 1940: 208.
60. Fowler, Proc. Acad. nat. Sci. Philad., *85*, 1933: 241, fig. 6; Bull. U. S. nat. Mus., 100 (*13*), 1941: 455, 456, fig. 12.
61. Smith, N. C. geol. econ. Surv., *2*, 1907: 45.
62. Our Study Material includes three embryos from South Carolina, 185–200 mm wide, about ready for birth, with swollen abdomens but with the umbilical scar wholly obliterated; their identity as *G. micrura* is established by their lack of spiracular tentacles or tail spines.
63. Gudger, Proc. biol. Soc. Wash., *26*, 1913: 100, as *Pteroplatea maclura*; Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 277.
64. A Butterfly Ray 52 inches wide (1,320 mm) has been reported as *G. micrura* from Virginia (Fowler, Occ. Pap. Mus. Zool. Univ. Mich., 56, 1918: 16), but without mention of the larger-growing *G. altavela*. While a New York specimen, doubtless *G. micrura* because it was described as having no spiracular tentacles, was credited with a breadth of two meters by Duméril (Hist. Nat. Poiss., *1*, 1865: 615, as *Pteroplatea maclura*); this seems to have been an error, since the same specimen had earlier been termed small by Müller and Henle (Plagiost., 1841: 170).

Indeed, it often moves in on the flood tide over flats that are laid bare on the ebb, withdrawing again as the tide falls.[65] The greatest distance out from the coast where *G. micrura* has been recorded definitely[66] is about 22 miles.

Since *G. micrura* occurs commonly along the northern coast of South America and has been definitely recorded from water as warm as 29.5–30° C (85–86° F) in the Gulf of Mexico off Texas, it is at home in the highest of tropical sea temperatures. The seasonal limits of its presence in Chesapeake Bay (May to late November, p. 413) suggest that its vernal dispersal northward along the United States Coast and its autumnal withdrawal roughly coincide with the corresponding shifts of the isotherm for about 15–16° C (59–60° F). *G. micrura* has not been reported from fresh water, but its presence in estuarine situations in French Guiana and Florida (Indian River) suggests that it may occur in brackish water. On the other hand, it has been reported from water of full oceanic salinity.[67]

Presumably *G. micrura* is a year-round resident in tropical South American waters, in the West Indian region, and as far north as southern Florida. It has long been known, however, that it visits the immediate shore waters of North Carolina only during the warmer part of the year,[68] although its recent capture off Cape Lookout in February shows that some may winter that far north, offshore. In Chesapeake Bay it is taken from May until November, our latest date for it there being November 28.[69] The few captures from farther north for which definite dates are recorded have been limited to the months of July,[70] August,[71] and September.[72]

The Lesser Butterfly Rays that visit the Middle Atlantic Coast of the United States are known to produce young from late May through July and into August,[73] and they may do so still later in the season for all that is known to the contrary. In the tropical parts of its range, where the water temperature changes but little from season to season, newborn *G. micrura* may be expected throughout the year.

Numerical Abundance. See *Details of Occurrence*, p. 414.

Relation to Man. It is sometimes used for human food in French Guiana and perhaps in other tropical localities; and its wings are used to a limited extent as bait by the crab fishery in Chesapeake Bay. It is perfectly harmless, since it lacks a tail spine.

Range. Coastal waters of the tropical warm-temperate belt of the western Atlantic from Brazil to Chesapeake Bay and outer coast of Maryland, northward occasionally to New York and to southern New England (Woods Hole); it is also listed for tropical

65. A Butterfly Ray has been recorded (Manter, Yearb. Carneg. Instn., 31, 1932: 288, as *Pteroplatea maclura*) from 60 fathoms off the Tortugas, Florida. But there is no way of knowing whether it was *G. micrura* or *G. altavela*.
66. Two specimens, 740 and 780 mm wide, were trawled by the U. S. Fish and Wildlife Service vessel ALBATROSS III off Cape Lookout, North Carolina, in Lat. 34°24′ N, Long. 76°04′ W, at a depth of 24 fathoms, February 19, 1950; bottom temperature 20.7° C (69.2° F).
67. 36.5–36.7 ‰, in the Gulf of Mexico off Aransas Pass, Texas (Gunter, Publ. Inst. mar. Sci. Texas, *1* [1], 1945: 23).
68. Data as to dates of arrival and departure for North Carolina waters are lacking.
69. Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 68.
70. Sandy Hook Bay, New Jersey; Narragansett Bay, Rhode Island; Woods Hole region, Massachusetts.
71. Ocean City, Maryland; Sandy Hook Bay, New Jersey; Buzzards Bay, Massachusetts.
72. Buzzards Bay; Massachusetts.
73. Recorded dates are May 27, July 27, and August 11 for North Carolina; July 24 in Chesapeake Bay.

West Africa,[74] but without positive evidence of specific identity. It is represented in South African, Indian, East Indian, Australian, and East Asiatic waters by a close relative, or relatives (see discussion, p. 412).

Details of Occurrence.[75] Published records that are positively identifiable as to species, combined with the geographic distribution of the specimens we have examined (see Study Material, p. 408), establish the presence of *G. micrura* near Rio de Janeiro, Brazil; French Guiana; Surinam (Dutch Guiana); Trinidad; Gulf of Campeche, Mexico; Texas, including the vicinity of Corpus Christi, offing of Aransas Bay, and Galveston; Grande Isle, Barataria Bay and its offing, and Main Island, Louisiana; Apalachicola, Tampa, Captiva Bay, and vicinity of Smyrna, Florida; Charleston, South Carolina; the Cape Lookout-Beaufort region, North Carolina; Chesapeake Bay and neighboring outer coasts of Virginia and Maryland; Cape May County and Sandy Hook Bay, New Jersey; and Woods Hole in southern Massachusetts, which marks the extreme boundary of its known range. It is probable that most of the reports of *Pteroplatea maclura* from other Texas-Louisiana-Florida localities (Galveston, Cameron, Lemon Bay near Englewood, Sarasota Bay, Dry Tortugas, Indian River) were also based on specimens of *G. micrura*, for this species is known to occur much more frequently along the coasts of the United States than does *G. altavela*.

Published statements as to the numerical abundance of *G. micrura*, added to our own observations, suggest that its center of abundance lies in the northern part of its range. Thus, knowledge of its presence on the Brazilian coast appears to rest on two or three well identified specimens only, and it is described as much less common in French Guiana coastal waters than is the Long-tailed Ray, *Dasyatis say*. But it has been classed as fairly common near Galveston, Texas, whence we have received 13 specimens. Although only two were taken among 144,000 other fishes trawled in Louisiana waters,[76] it is common enough there locally to be advertised as "available in quantities."[77]

Neither the printed record nor our own experience suggest any concentrations of them along the Florida Coast. But they are reported as common in the vicinity of Beaufort and of Cape Lookout, North Carolina. At Lynnhaven Roads in the lower part of Chesapeake Bay, where we have seen many hundreds taken, 40 individuals are often caught in a single pound net during a 24-hour period. But to the northward all of the published records of it have been based on stray specimens only.

Synonyms and Atlantic References:[78]

Raja micrura Bloch and Schneider, Syst. Ichthyol., 1801: 360 (diagn., color, Surinam [Dutch Guiana]).[79]

74. For West African references, nominally to *G. micrura*, see Fowler (Bull. Amer. Mus. nat. Hist., 70 [1], 1936: 132). The accompanying specific description was for a specimen from the Middle Atlantic United States.
75. Many of the reports of Butterfly Rays in the western Atlantic might refer either to the present species or to *G. altavela*.
76. Gunter, Publ. Inst. mar. Sci. Texas, 1 (1), 1945: 23. 77. Carolina Biol. Supply Co., Cat. 20, 1949–1950: 115.
78. This list is confined to Atlantic references that seem referable to *G. micrura* with reasonable assurance, as contrasted with *G. altavela*, whether by included evidence of one sort or another or by reference to some previous author. For discussion of the relationship of Pacific and Indian ocean Butterfly Rays of the *micrura* type to *G. micrura* of the western Atlantic, see p. 411.
79. Bloch and Schneider's account of the tail as black- and white-barred ("nigro alboque fasciata") is not in itself con-

Trygon micrura Müller, Faunus, Z. Zool., Vergl. Anat., herausg. Gistel, N. S. *1*, 1837: 40 (Rio de Janeiro, ident. probable because said to agree with descr. of *Raja micrura* by Bloch and Schneider 1801).

Pteroplatea maclura Müller and Henle, Plagiost., 1841: 169 (descr., meas., size, Brazil, Surinam [Dutch Guiana], New York); Duméril, Hist. Nat. Poiss., *1*, 1865: 614 (descr., Brazil, New York, same specimen as in Müller and Henle, 1841, but max. size probably erroneous; see discussion, p. 412, fn. 64); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 487 (descr., Brazil, Texas specimens); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 46 (descr., Virginia to Brazil); Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 86 (descr., color, Long Island, New York to Brazil); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, Rhode Island to Brazil); Linton, Bull. U. S. Bur. Fish., *24*, 1905: 348 (stom. contents, Beaufort, N. Carolina); Smith, N. C. geol. econ. Surv., *2*, 1907: 45 (descr., nos., size of gravid females and newborn, no. of young, N. Carolina, but max. size given is probably not for this species); Wilson, Proc. U. S. nat. Mus., *33*, 1908: 626 (copepod parasites, Beaufort, N. Carolina); Gudger, Amer. Nat., *44*, 1910: 401 (uterine gestation); Weymouth, Proc. U. S. nat. Mus., *38*, 1910: 135 (no. dark tail bands, size, Cameron, Louisiana); Gudger, Science, N. S. *33*, 1911: 943 (tail of embryo); Proc. biol. Soc. Wash., *25*, 1912: 148 (uterine wall, eggs, embryos, no. young, claspers, absence of tail spine, size of gravid females, Beaufort, N. Carolina); Fowler, Copeia, 2, 1913: 3 (listed, Ocean City, Maryland); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 100 (size of gravid females, ovaries and eggs, Beaufort, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (nos., size, C. Lookout, N. Carolina); Mast, Bull. U. S. Bur. Fish., *34*, 1916: 181 (color adapt. to background); Coker, Copeia, 110, 1922: 65 (without tail spine); Breder, Copeia, 153, 1926: 122 (size, eggs, Sandy Hook Bay, New Jersey); Nichols and Breder, Zoologica N. Y., *9*, 1927: 27 (size, food, Sandy Hook Bay and Woods Hole); Gudger, Copeia, 1933: 186 (one without tail, Beaufort, N. Carolina); Breder and Nigrelli, Copeia, 1934: 193 (listed, Sandy Hook Bay); Puyo, Bull. Soc. Hist. nat. Toulouse, *70*, 1936: 79, 250 (cf. Pacific species, descr., color, nos., habits, util., French Guiana); Breder, Bull. N. Y. zool. Soc., *41*, 1938: 28 (listed, New York Harbor).

Pteroplatea maclura (in part) Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 799 (*G. altavela* also included by ref. to *G. maclura* [Lesueur] 1817).

Pteroplatea micrura Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 414, pl. 33, figs. 3, 4 (descr., ill.); Ehrenbaum, Fischerbote, 1914: 407 (listed, Cameroon; not seen); Kustenfische Westafrika, 1915: 73 (not seen); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 276, pl. 47, figs. 1, 2 (ill. teeth, photos adult, embryo, size of gravid female, uterine wall, nourishment of embryo, eggs, absence of tail spine, nos., Beaufort, N. Carolina); Metzelaar, Trop. Atlant. Visschen, 1919: 8, 199 (listed, Trinidad, perhaps Curaçao); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 146 (listed, C. May County, New Jersey); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 87 (descr., color, no Panama record); Monod, Faune Colon. Franç., 1927: 650 (W. Africa; not seen); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 67, fig. 37 (descr., color, size, photo, nos., season, util., Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 36 (size, ill.); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn., absence of tail spine); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 29 (listed, Rhode Island to Brazil); Breder, Copeia, 1931: 39 (listed, Sandy Hook Bay, New Jersey); Fowler, Copeia, 1931: 46 (listed, Port Aransas, near Corpus Christi, Texas); Beltran, List. Peces Mexicanos, 1934: 10 (listed, Mexico; not seen); Chamberlain, Copeia, 1934: 42 (mutilation by fishermen, S. Carolina); Ranzi, Pubbl. Staz. zool. Napoli, *13* (3), 1934: 407 (uterine wall and secretion); Gunter, Copeia, 1935: 39 (listed, Barataria Bay, Louisiana, and Gulf of Mexico); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 132 (W. Afr. refs., descr. of mid-Atlant. U. S. specimen); Gunter, Amer. Midl. Nat., *26*, 1941: 196 (listed, Louisiana); Publ. Inst. mar. Sci. Texas, *1*, 1945: 23 (temp., sal., nos., off Aransas Pass, Texas, and Barataria Bay, Louisiana); Hildebrand, Bull. U. S. nat. Mus., 189, 1946: 73–74 (cf. *G. afuerae* [Hildebrand] 1946, Peru).

clusive evidence that their *R. micrura* was based on the Ray here considered rather than on its larger relative *Gymnura altavela* (Linnaeus) 1758, for at least the tail of young specimens of the latter is also cross-barred with dark and light (p. 403). We think, however, that Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 414) was justified in employing the name *micrura* for the Lesser Butterfly Ray of the western Atlantic, for the latter is known to occur commonly along the northern shores of South America (French Guiana), where *G. altavela* has not been reported. On the other hand, Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 455) has recently characterized the type locality (Surinam, Dutch Guiana) given by Bloch and Schneider for their *R. micrura* as "likely erroneous" and has therefore followed Cantor (J. Asiat. Soc. Beng., *18*, 1849: 1409) and others in applying the specific name *micrura* to an Indo-Pacific Butterfly Ray, discussed on p. 411.

Pteroplatea micrura (perhaps only in part) Fowler, Occ. Pap., Mus. Zool. Univ. Mich., 56, 1918: 16 (*G. altavela* perhaps included because reported up to 1,320 mm wide, Smiths I., Virginia).

Gymnura altavela Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 162, 199 (near Charleston, S. Carolina, and Beaufort, N. Carolina; embryos[80] 180–197 mm wide from 9 lb. mother are *G. micrura*, see p. 405).

Probable References:

Pteroplatea maclura Moseley, Rep. Va. Fish. Comm., 1877: 9 (listed, Norfolk, Virginia); Yarrow, Proc. Acad. nat. Sci. Philad., *29*, 1877: 216 (nos., season, near Beaufort, N. Carolina); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1882: 160 (listed, S. Carolina); Jenkins, Johns Hopkins Univ. Stud. Biol., *4*, 1887: 84 (nos., Beaufort, N. Carolina); Bean, Proc. U. S. nat. Mus., *14*, 1891: 94 (size, capture, Chesapeake Bay); Wilson, Amer. Nat., *34*, 1900: 355 (nos., Beaufort, N. Carolina); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 32 (listed, Worcester County, Maryland); Bere, Amer. Midl. Nat., *17*, 1936: 590, 606 (copepod parasites, Lemon Bay, W. Florida); Pearse, J. Elisha Mitchell sci. Soc., *52*, 1936: 211 (listed, Core Sound, N. Carolina).

Not *Raja maclura* Lesueur, J. Acad. nat. Sci. Philad., *1*, 1817: 41, pl. not numbered (descr., color, ill., Newport, Rhode Island; almost certainly *G. altavela*; see p. 406).

Not *Trygon maclura* Cuvier, Règne Anim., *2*, 1829: 400, footnote (ref. to Lesueur, 1817); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 5 (descr. for Rhode Island after Lesueur 1817, but ref. for Connecticut after Linsley 1844; not *Gymnura*).

Not *Pteroplatea micrura* Müller and Henle, Plagiost., 1841: 169 (E. Indies, Java, probably equals *Gymnura poecilura* [Shaw] 1804).

Not *Pastinaca maclura* DeKay, Zool. N.Y., 4, 1842: 375, pl. 65, fig. 213 (descr., ill., size, by ref. to Lesueur, 1817, equals *G. altavela*); Linsley, Amer. J. Sci., *47*, 1844: 77 (listed, Connecticut; probably *Dasyatis centroura* because of large size).

Not *Pteroplatea maclura* von Ihering, Rev. Mus. paul., *2*, 1897: 36 (descr., stom. contents, Rio Grande do Sul, Brazil; descr. with two tail spines but no spiracular tentacle, thus probably *G. hirundo* [Lowe] 1843; see p. 398); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 182 (descr. of specimen reported by von Ihering 1897); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 38 (same as Ribeiro 1907); Devincenzi, Rev. chil. Hist. nat., *29*, 1925: 170; An. Mus. Hist. nat. Montevideo, (2) *2*, 1926: 202; Devincenzi and Barattini, An. Mus. Hist. nat. Montevideo, (2) *2*, Suppl. Album Ictiol., 1926: pl. 4, fig. 3; Pozzi and Bordale, An Soc. cient. argent., 120, 1935: 154 (equals *Gymnura altavela*, which see, p. 407).

References applicable either to *G. micrura* or to *G. altavela*; no evidence as to identity:

Pteroplatea maclura Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed, E. Coast N. Amer.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole); Gill, Smithson. misc. Coll., *14*, 1873: 34 (listed, E. Coast U. S.); Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (listed, Indian R., Florida); Goode and Bean, Proc. U. S. nat. Mus., *5*, 1883: 240 (listed, Gulf of Mexico); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 260 (listed, S. Carolina); Henshall, Bull. U. S. Fish Comm., *14*, 1895: 210 (listed, Florida); Bean, Bull. Amer. Mus. nat. Hist., *9*, 1897: 331 (listed, Gravesend Bay, New York); Evermann and Bean, Rep. U. S. Comm. Fish. (1896), 1898: 240 (listed, Indian R., Florida, by ref. to Goode, 1879); Smith, Bull. U. S. Fish Comm., *17*, 1898: 90 (Woods Hole); Evermann and Kendall, Rep. U. S. Comm. Fish. (1889), 1900: 50 (listed, Indian R., Florida); Bean, Bull. N.Y. St. Mus., 60, Zool. *9*, 1903: 56 (descr., *G. micrura* and *G. altavela* apparently combined); Gilbert and Starks, Mem. Calif. Acad. Sci., *4*, 1904: 18 (cf. Pacif. species); Fowler, Copeia, 2, 1913: [2] (listed, Maryland); Nichols, Abstr. Linn. Soc. NY., 20–23, 1913: 92 (listed, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31*, 1913: 739 (food, season, near Woods Hole); Manter, Yearb. Carneg. Instn., 31, 1932: 288 (trematode parasites, Tortugas, Florida, 60 fath.).

Family UROLOPHIDAE

Characters. Myliobatoidea with well developed caudal fin supported by cartilaginous rays. Tail from center of cloaca a little longer than body in some but shorter

80. Loaned to us by Charleston Museum.

than body in most; tail with a large saw-edged spine (or spines). Front of cranium weakly indented in midline, its outer corners broadly rounded. Pelvis moderately arched in subangular contour, without median process. Surfaces of gill arches smooth inward from gill filaments. Characters otherwise as in the Dasyatidae.

Remarks. All of these small Rays, the largest only about 30 inches long, are much alike in general appearance. They are inhabitants of moderately shoal water from only a few feet down to about 30–40 fathoms,[81] perhaps deeper. When they are in water shallow enough for observation, they are commonly found partly buried in the sand or mud of the bottom, and, like their longer-tailed relatives of the family Dasyatidae, they are said to scoop out holes in the sand with their pectoral fins, thus dislodging worms and crustaceans on which they feed. In some places they are so numerous in shoal water that the bottom can almost be described as paved with them. Under such circumstances they are dangerous to fishermen wading on the flats, for they are well armed and it is probable that their tail spines are venomous, as are those of the long-tailed Sting Rays, though this has not actually been tested for them by clinical experiment.

Range. The geographic range of the family includes: the western Pacific from Japan and Korea to southern Australia and Tasmania, including the East Indies; the coasts of the eastern Pacific from southern California (Cape Conception) to Chile; and the western Atlantic from Florida (occasionally North Carolina) to the southern side of the Caribbean and perhaps farther south along the Atlantic Coast of South America.[82]

Recent synopses credit the western Pacific area with ten species,[83] the eastern side of the Pacific with nine,[84] while only three are known in the western Atlantic. Up to the present time, no member of the family has been reported either from the eastern side of the Atlantic or from the Indian or African coasts of the Indian Ocean.

Key to Genera

1 a. A small dorsal fin on tail anterior to spine in both adults and embryos. *Trygonoptera* Müller and Henle 1841. Tasmania, Australia, East Indies.

1 b. No dorsal fin in adults, though one is sometimes present in embryos.

2 a. Caudal fin not more than $^1/_6$ as broad as long; tail a little longer than body, each measured from center of cloaca. *Urotrygon* Gill 1863, p. 427.

2 b. Caudal fin more than $^1/_4$ as broad as long; tail no longer than body, each measured from center of cloaca. *Urolophus* Müller and Henle 1837, p. 418.

Remarks on Generic Definitions. Two recent authors, not using the dorsal fin as a basis for generic separation in this family, unite in *Urolophus* the two groups of species that are divided here between *Urolophus* and *Trygonoptera*.[85] However, we think it wiser

81. Thirty-three fathoms is the greatest depth for which we have found definite records of one of this group.
82. For further comment on this point, see p. 426.
83. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 440.
84. Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 264–271.
85. Whitley (Fish. Aust., *1*, 1940: 215–219); Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 439). The latter author recognizes two subgenera, *Urolophus* and *Trygonoptera*, separated by the length of the tail, however, and not by the presence or absence of a dorsal fin.

to retain both of these genera in recognition of the specific grouping that does exist in this respect, despite the facts that some specimens may show a rudimentary dorsal in one of the Australian species (*U. viridis* McCulloch 1916) in which it is usually lacking and that the dorsal fin may be lacking occasionally in another species from the same general region (*U. testaceous* Müller and Henle 1841) in which it is normally present.[86]

Also, retention of *Urotrygon* for the longer-tailed species group with narrower caudal, as contrasted with the shorter-tailed *Urolophus* with broader caudal, seems similarly justifiable for the time being on the basis of convenience, though it is likely that no definite line of demarkation can be drawn between the two. But the minor difference on which Garman[87] separated his new genus *Urobatis* ("snout not produced") from *Urolophus* ("snout little produced") seems to us to be of specific significance at most.

Genus *Urolophus* Müller and Henle 1837

Urolophus Müller and Henle, S. B. Akad. Wiss. Berl., 1837: 17; Charlesworth Mag. nat. Hist., *2*, 1838: 90; type species, *Raja cruciata* Lacépède, New Holland (old name for Australia), designated by Müller and Henle.

Generic Synonyms:

Raja (in part) Lacépède, Ann. Mus. Hist. nat. Paris, *4*, 1804: 110, for *Raja cruciata* Lacépède, Australia; Bancroft, Zool. J., *5*, 1830: 83, for *Trygon sloani*[88] Cuvier 1817.

Leiobatus Blainville, Bull. Soc. philom. Paris, 1816: 121; type species, *Raja cruciata* Lacépède 1804.[89]

Trygon (in part) Cuvier, Règne Anim., *2*, 1817: 137, footnote; for *T. jamaicensis* Cuvier, by ref. to Sloane (Hist. Jamaica, *2*, 1725: pl. 246, fig. 1).

Trygonobatus Desmarest, Mém. Soc. Linn. Paris, *2*, 1823: 6; type species, *T. torpedinus* Desmarest. Cuba.

Leiobatis Blainville, in Vieillot, Faune Franç., Poiss., 1825: 43; apparently emended spelling for *Leiobatus* Blainville 1816.

Urobatis Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 401; type species, *U. sloani* Garman,[90] designated by Garman. Haiti.

Urotrygon Breder, Bull. Bingham oceanogr. Coll., *1* (1), 1927: 6; for *Trygon jamaicensis* Cuvier 1817.

Not *Raja* Linnaeus, Syst. Nat., *1*, 1758, which see, p. 138.

Not *Leiobatus* Rafinesque, Caratt. Gen. Spec. Sicil., 1810: 16; equals *Rhinobatos* Link 1790, which see, p. 50.

Not *Trygonobatus* Blainville, Bull. Soc. philom. Paris, 1816: 112; equals *Dasyatis* Rafinesque (Caratt. Gen. Spec. Sicil., 1810: 16), which see, p. 340.

Not *Urotrygon* Gill, Proc. Acad. nat. Sci. Philad., 1863: 173; which see, p. 427.

Generic Characters. Disc ranging from a little longer than broad to about 1.25 times broader than long; lateral margins arcuate, without definite outer corners; median

86. In this we follow Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913).

87. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 401, 407.

88. Probably *jamaicensis* Cuvier 1817 was intended actually, for Cuvier never used the specific name *sloani*, so far as we can learn.

89. *Leiobatus sloani* Blainville, designated by Jordan (Genera Fish., *1*, 1917: 95) as type of Blainville's *Leiobatus*, was a *nomen nudum* and hence is not available. In its place we propose *L. cruciata* Blainville, equivalent to *Raja cruciata* Lacépède 1804, as the only one of the three nominal species included by Blainville, an account of which had appeared previously.

90. Probably this was the Ray referred to by Blainville (Bull. Soc. philom. Paris, 1816: 121) as *Leiobatus sloani* and by Bancroft (Zool. J., *5*, 1830: 83) as *Raja sloani*. But neither of these early notices was accompanied by any description or by any mention of Sloane's (Hist. Jamaica, *2*, 1725: 227, pl. 246, fig. 1) pre-Linnaean account of the Jamaican Ray to which they probably referred. Therefore *sloani* was a *nomen nudum* until revived by Garman in 1913.

anterior sector forming a blunt angle, with or without a low papilla marking tip of snout. Tail from center of cloaca not longer than body from center of cloaca to tip of snout; one or two formidable tail spines, their margins armed with sharp recurved teeth; tail without membranous folds above or below, apart from caudal fin. Usually no dorsal fin after birth, but embryos of some species may have one.[91] Caudal fin at least $^1/_4$ as broad as long, extending around tip of tail and supported by cartilaginous rays. Spiracles close behind eyes; embryos of at least some species with a well developed fleshy lobe or tentacle on inner margin of spiracle, directed outward across opening of latter, but this is lost either before birth or shortly thereafter. Nasal curtain with fringed margin; outer (morphologically posterior) margin of nostril smoothly rounded, not expanded, but inner (morphologically anterior) part with a fold projecting shelf-like toward nasal septum. Mouth small, transverse, its floor usually with five to nine fleshy papillae, its roof with a broad curtain-like transverse fold, deeply fringed with simple lobes. Teeth small, numerous, up to 10–12 rows in function simultaneously. Upper surface of disc and of tail either wholly naked apart from tail spines or roughened with small spines or tubercles along midzone and on shoulders. Characters otherwise those of the family.

Developmental Stages. In the Australian *Urolophus testaceous*, and probably in other members of the genus as well, the walls of the uteri of gravid females are clothed with long filiform villi, richly supplied with blood vessels. It has been suggested that the external gills of early embryos may absorb nourishment from these villi, with which they become entwined.[92]

Range. Shallow coastal waters in western tropical and subtropical Atlantic; eastern North Pacific from Gulf of Panama to southern California (Point Conception); Japan and Korea; Malay Archipelago (Ki Islands); Victoria, New South Wales, South Australia, and Tasmania.

Species. Recent surveys[93] recognize seven (perhaps eight[94]) species of *Urolophus*, as here defined, in the western Pacific-Australian region and three along the eastern shores of the Pacific, besides the one (*U. jamaicensis*) that occurs in the Atlantic. They fall in two groups: A. Those with midbelt of disc more or less roughened with tubercles from soon after birth. This subdivision includes *U. jamaicensis* (Cuvier) 1817 of the Atlantic and *U. armatus* Müller and Henle 1841 (if this is actually a species of the genus *Urolophus* rather than of *Trygonoptera* with dorsal fin[95]), known only from the Bismarck Archipelago. B. With skin wholly naked apart from tail spines. The members of this group stand in obvious need of a critical revision which we are not in a position to attempt.

91. Some embryos of *Urolophus cruciatus* from Australian waters have a small dorsal fin, but others in the same litter may not (Whitley, Fish. Aust., *1*, 1940: 215, 216).
92. See Haswell, Proc. Linn. Soc. N. S. W., *3*, 1889: 1716.
93. Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 269) as *Urobatis*; Whitley, Fish. Aust., *1*, 1940: 215; Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 440.
94. Firsthand descriptions of *U. armatus* Müller and Henle 1841 from New Ireland, Bismarck Group, fail to state specifically whether it does or does not have a dorsal fin.
95. See p. 417, footnote 85.

Urolophus jamaicensis (Cuvier) 1817[96]

Figures 99, 100

Study Material. Thirty-nine specimens,[97] male and female, 120 to about 445 mm long, late embryos to adults, from Cuba; Haiti; Trinidad; Jamaica; Old and New Providence and Bimini in the Bahamas; Progresso, Yucatán; Key West, and southeastern Florida; in the U.S. National Museum and the Harvard Museum of Comparative Zoology.

Distinctive Characters. A well developed caudal fin extending around the tip of the tail, combined with a formidable tail spine, mark *Urolophus jamaicensis* off from all other Rays of the western Atlantic, except for its close relatives *Urotrygon microphthalmum* and *Urotrygon venezuelae*. There is little danger of confusing it with the first of these, for *U. jamaicensis* is arcuate in front, or at least very obtuse, the snout in front of the eyes is only a little longer than the distance between the eyes, and its pelvics are rounded, whereas *Urotrygon microphthalmum* is angular in front, the pointed snout is about twice as long in front of eyes as the distance between eyes, and the pelvics are squarish with angular corners (*cf.* Fig. 99 with 101). Obvious features that separate *Urolophus jamaicensis* from *Urotrygon venezuelae* (which it resembles in appearance) are that its tail from center of cloaca is shorter than its body from cloaca to snout (longer in *Urotrygon venezuelae*), its disc is considerably narrower relatively, and the tip of its snout is less prominent (*cf.* Fig. 99 with 101α).

Description. Proportional dimensions in per cent of total length. Male, 328 mm long from the Bahamas (Harv. Mus. Comp. Zool., No. 1153). Female, 375 mm long, from near Palm Beach, Florida (Harv. Mus. Comp. Zool., No. 36399).

Disc: extreme breadth 51.5, 55.5; length 58.2, 59.7.
Snout length: in front of orbits 11.0, 11.7; in front of mouth 11.9, 10.4.
Orbits: horizontal diameter 5.5, 4.8; distance between 5.2, 4.5.
Spiracles: length 4.0, 3.9; distance between 8.5, 8.3.
Mouth: breadth 5.0, 7.2.
Exposed nostrils: distance between inner ends 5.3, 5.5.
Gill openings: lengths, 1st 1.8, 2.0; 3rd 2.0, 2.4; 5th 1.2, 1.3; distance between inner ends, 1st 11.6, 12.8; 5th 8.5, 9.3.
Pelvics: anterior margin 10.7, 11.7.
Distance: from tip of snout to center of cloaca 51.8, 53.8; from center of cloaca to origin of caudal spine 26.8, 27.4; to tip of tail 48.2, 46.2.

Disc about as broad as long in late embryos, but a little longer than broad after birth (averaging about 1.1 times as long as broad in series examined); ovoid in general form, the anterior contour ranging from obtusely subangular with snout hardly projecting to almost evenly arcuate; lateral margins nearly evenly rounded, without any sug-

96. For reasons why this name is used rather than *U. sloani* Blainville 1816, see p. 427, footnote 10.
97. Including the types of the variety *U. vermiculatus* of Garman, 1913.

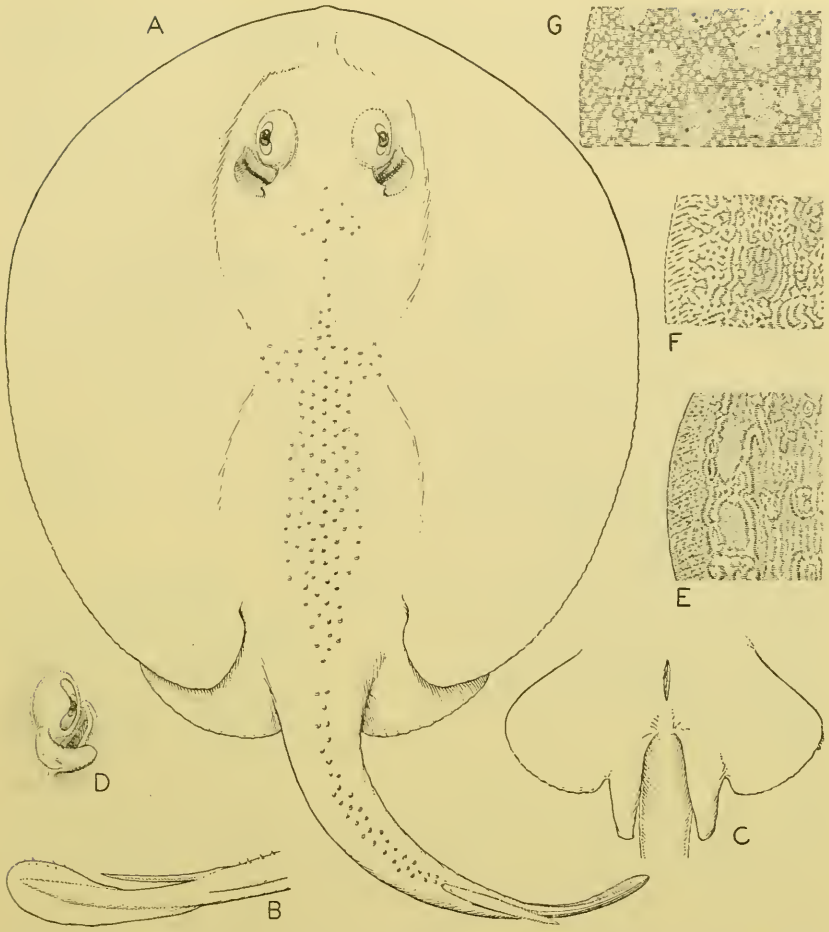

FIGURE 99. *Urolophus jamaicensis*. *A* Female, 375 mm long, from Palm Beach, Florida (Harv. Mus. Comp. Zool., No. 36399). *B* Side view of rear end of tail of same. *C* Ventral view of pelvic fins of male, 325 mm long, from Indian Key, Florida (Harv. Mus. Comp. Zool., No. 33). *D* Eye and spiracle of embryo, 122 mm long, from Cuba (Harv. Mus. Comp. Zool., No. 576A) to show spiracular tentacle. *E* Margin of disc opposite shoulders of male, about 200 mm long, from Old Providence, Bahamas (U. S. Nat. Mus., No. 38642) to show color pattern. *F* Same of male, 321 mm long, from Progresso, Yucatán (Harv. Mus. Comp. Zool., No. 1055). *G* Same of female, 375 mm long, from Palm Beach, Florida (Harv. Mus. Comp. Zool., No. 36399); *E–G* About 0.5×.

gestion of outer corners; posterior corners moderately rounded; inner margins weakly convex. Axis of greatest breadth about 40 % of distance back from tip of snout toward

rear limits of disc. Tail from center of cloaca about as long as distance from center of cloaca to tip of snout, or a little shorter; its basal portion, anterior to spine, tapering gently and flattened moderately dorsoventrally, each side with a low but definitely marked dermal ridge or keel.

Tail spine about as long as snout in front of orbits, or about half as long as distance from its origin to center of cloaca; its origin a little posterior to midlength of tail from center of cloaca; spine with about 20–25 recurved and sharp lateral teeth toward tip but smooth-edged along basal $^1/_5$ to $^1/_4$ of its length; only one spine on specimens examined, but sometimes two.[98]

Skin, apart from tail spine, naked in embryos; but midbelt of back, from nuchal region rearward, roughened from soon after birth by low blunt tubercles, sparsely scattered finally in three or four irregular rows on disc and in four or five rows on tail rearward to spine; those along tail somewhat the largest in some cases; a series of rather stronger recurved thorns also developing close along dorsal margin of caudal fin on either side; large specimens with mid-dorsal tubercles extending forward to level of posterior parts of orbits and to zone between eyes, or even a little farther in some; thorny belt finally expanding laterally to cover an irregular area over each shoulder. But naked patches sometimes develop on the posterior part of the disc as maturity is approached, perhaps more often on females than on males.[99] Lower surfaces of both disc and tail naked.

Snout in front of orbits about as long as distance between outer margins of orbits, its length in front of mouth about 1.9–2.2 times as great as distance between exposed nostrils and 0.8–1.0 times as great as distance between inner ends of first gill openings. Orbit about as long as distance between orbits. Spiracle close behind orbit, about 0.7–0.8 times as long as orbit, its inner margin with a low knob reminiscent of the embryonic spiracular lobe (described under Developmental Stages, p. 425). Distance between inner ends of first gill openings 2.2–2.3 times as great as distance between exposed nostrils; distance between inner ends of fifth pair about 73–75 % as long as distance between first pair. Nasal curtain reaching to mouth, its margin weakly and evenly arcuate, fringed with a close-set series of short lobes with secondarily fringed margins (Fig. 100A). Mouth nearly straight. Floor of mouth with 3–5 papillae.

Teeth $\frac{30-34}{28-30}$ (two specimens); those of young of both sexes and of females to maturity close-set in quincunx; low and narrow-oval, their long axes parallel with jaw; the functional surface with deep furrow from side to side, and somewhat irregular in outline; teeth of sexually mature males somewhat more loosely spaced, with high conical cusp, slightly blunted at tip; about 4–6 rows in upper jaw and 7–9 rows in lower in function simultaneously.

Caudal fin broadly rounded at tip, with weakly convex upper and lower margins, about equally wide above axis as below, its greatest breadth about $^1/_3$–$^1/_4$ as great as its length along ventral margin; its ventral origin under or a little posterior to origin

98. Duerden, J. Inst. Jamaica, *2*, 1895: 166; Fowler, Rep. N. J. Mus. (1906), 1907: pl. 78.
99. There appears to be no definite sexual contrast in this respect.

of tail spine; its dorsal lobe, originating about under tip of spine, about half as long as its ventral lobe; supporting rays evident when viewed against a strong light or when partially dried. Pelvics extending rearward beyond posterior levels of pectorals for a distance a little less than half the distance between eyes; anterior margin nearly straight; posterior (distal) margin moderately convex; corners broadly rounded; anterior margin about 60–65 % as long as distance from pelvic origin to rear corner. Claspers of mature

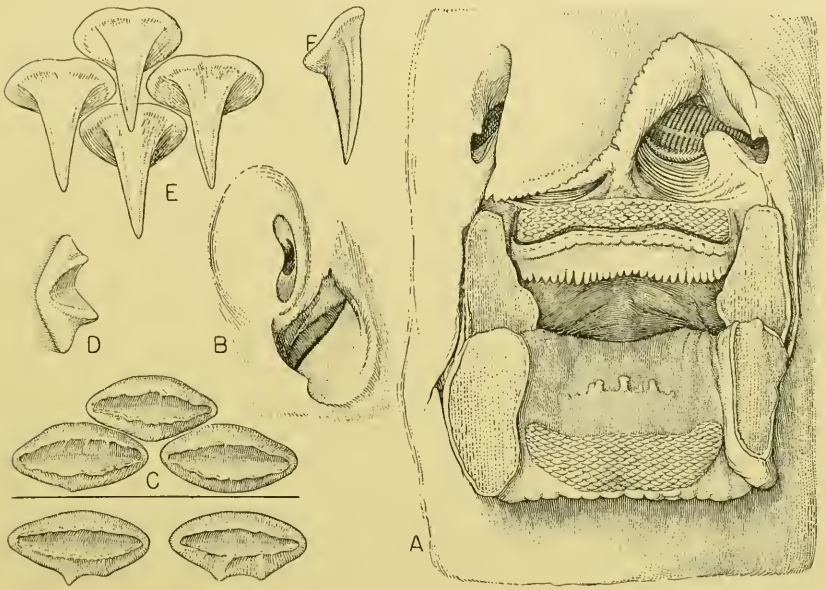

FIGURE 100. *Urolophus jamaicensis*. *A* Opened mouth (cut at corners) of female, 375 mm long, from Palm Beach, Florida (Harv. Mus. Comp. Zool., No. 36399), with left-hand nasal curtain rolled forward to show nostrils, tooth bands, transverse curtain on roof of mouth, and papillae on floor of mouth, about 1.7×. *B* Eye and spiracle of same, about 1.3×. *C* Front upper teeth (above the line) and rear upper teeth (below the line) of same, about 22×. *D* Side view of upper tooth of same, about 22×. *E* Upper teeth of mature male, about 325 mm long, from Indian Key, Florida (Harv. Mus. Comp. Zool., No. 33), about 20×. *F* Side view of one tooth of same, about 17×.

male rather robust, with rounded tips, without projecting hooks, extending beyond rear limits of pelvics for a distance about half as long as anterior (outer) margins of pelvics.

Color. The upper surfaces of the disc and tail (including caudal fin) usually have a fine-meshed reticulate pattern of dark greenish, pinkish, or ashy brown on a pale background; or conversely, they have a close-set pattern of small pale whitish, yellowish or golden spots on a dark ground of one of the tints just stated. However, individuals vary widely in color and in pattern, even among series taken at the same locality and at

the same time; while some are quite definitely pale-spotted and others are definitely dark-meshed, still others exhibit various intermediate stages on different parts of their discs, with dark striping extending radially toward the margins. Again, on some the pattern may consist of a meshwork of broad bands whereas on others there are chains of alternating dark dots and pale spaces on a background of intermediate shade. Or the midzone of the disc may be plain brown while the outer belt is marked with darker reticulations and pale bands, arranged longitudinally toward the central part of the disc but radially toward the margins. On some specimens the dark markings take the form of vermiculations rather than of a network or of stripes.[100] On some, the outer belt of the disc is variegated by an irregular series of large roundish pale areas, while dark cloudings, irregular in size or shape, may or may not involve the regions of the shoulders, eyes, and spiracles. The inner parts of the pelvics have pale spots or dark reticulations or vermiculations on a pale ground, and their outer margins are more or less definitely dark-striped in radial pattern.

The lower surface is yellowish, greenish or brownish white, the tail irregularly marked with dark dots and larger spots; the outer zone of the disc has small dots of the same hue as the dark areas on the back, either close along its extreme outer margin only or extending inward over a band varying in breadth from specimen to specimen. The pelvics are similarly dark-dotted below toward their posterior margins, combined in some cases with an irregular pattern of dark radial stripes. The lower surfaces of the claspers are plain whitish in some specimens but variously dark-spotted in others. No evidence has been reported of adaptive changes in the color pattern on different backgrounds.[101]

Relationship to Extralimital Species. Among Rays of the Pacific Coast of America, *U. jamaicensis* resembles *U. halleri* most nearly. Indeed, we have found no sharpcut criterion by which newborn specimens of the two can be separated with certainty. However, quarter-grown specimens and larger are made easily identifiable as one or the other by the fact that the midzone of the back, from the level of the front of the eyes rearward to the tail spine, is rough with low tubercles on *U. jamaicensis* but perfectly smooth on *U. halleri.* A less obvious difference, seemingly as reliable, is that the disc is a little longer than broad in half-grown and larger specimens of *U. jamaicensis* but about as broad as long in *U. halleri.*

Among western Pacific urolophids, *U. jamaicensis* is paralleled by *U. armatus* Müller and Henle 1841 of the Bismarck Archipelago in the roughness of its back. But the two species differ in shape, *U. armatus* having a pointed and prominent snout, a disc rectilinear in anterior outlines, dermal armature consisting of small prickles, and a single large median tubercle over the pectoral girdle.[102]

100. Three specimens of this type were christened *vermiculatus* var. nov. by Garman and were beautifully pictured by him (Mem. Harv. Mus. comp. Zool., *36*, 1913: 402, pl. 29). But in all respects other than the color pattern, they are typical *U. jamaicensis*, hence they appear to represent merely an extreme color-variant of the latter.

101. An allied Australian species, *Trygonoptera testacea* Müller and Henle 1841, failed to show any adaptive changes in tint on a black background, although its melanophores expanded after the injection of pituitary extract (Griffiths, Proc. Linn. Soc. N. S. W., *61*, 1926: 318).

102. For firsthand descriptions of the type specimen of *U. armatus*, see Müller and Henle (Plagiost., 1841: 174), and Duméril (Hist. Nat. Poiss., *1*, 1865: 628).

Size. The condition of the claspers suggests that males become sexually mature at a width of about 150–160 mm.[103] The largest specimens reported thus far (from Key West, Florida)[104] were 305–355 mm wide, or about 600–670 mm long.

Developmental Stages. Relative to their length, the discs of embryos are a little broader than those of adults. Embryos also differ from their parents in their wholly naked skins (see pp. 419, 422). However, the most interesting embryonic feature is the presence of a well developed fleshy lobe or tentacle on the inner margin of each spiracle close behind the eye. It is about as long as the spiracle itself and is directed outward across the latter so that it conceals most of the spiracular opening.[105] But it appears that this lobe is resorbed either just before birth or shortly thereafter, for it is represented by only a low swelling or knob on even the smallest of the free-living specimens that we have examined. This embryonic structure is characteristic of other species of *Urolophus*, and of *Urotrygon* as well, for we have found it equally developed on embryos of *Urolophus halleri* Cooper 1863 from southern California and on those of *Urotrygon aspidurus* (Jordan and Gilbert) 1881 from Panama. There is no dorsal fin on the embryos of *Urolophus jamaicensis* examined, or on those of *Urotrygon aspidurus*, but one is sometimes present on embryos of *Urolophus cruciatus* (Lacépède) 1804[106] of Australia.

Females of *U. jamaicensis* have been recorded as giving birth to two or three young, and those that we have examined contained three and four embryos each.

Habits. U. jamaicensis appears to be confined to shoal water, most frequently (perhaps exclusively) on sandy or muddy bottom, most of the recorded captures of it having been made in harbors or bays, where it is often taken in seines along shore as well as in baited traps and on hook and line. Its method of securing its prey, not yet observed, may resemble that of the closely allied *U. halleri* of the Pacific Coast (southern California to Panama), which is "found on the bottom, nearly buried in loose sand or mud," and which is "said to scoop out large holes in mud banks by waving the pectoral fins, eating the worms, crabs, and small fishes thus exposed."[107] The only specimens for which the stomach contents have been recorded contained shrimps (*Penaeus brasiliensis*) in one case, bottom detritus in another.

A large male taken in Haitian waters was in breeding condition in March.

Numerical Abundance. No precise information is available as to the numbers of *U. jamaicensis* for any part of its range. Although it is plentiful enough for fishermen to dread it in Jamaican waters, at most it has been reported as common at West Indian localities, suggesting that it is not as abundant on the whole as its relative *U. halleri* is along the Pacific Coast of Central America. Our observations around Bimini, Bahamas, have indicated that it is seen or captured only occasionally there.

103. One of this sex, with disc 190 mm long, has been described previously as in breeding condition (Beebe and Tee-Van, Zoologica N. Y., *10*, 1928: 30).
104. Fowler, Monogr. Acad. nat. Sci. Philad., *7*, 1945: 265.
105. The presence of this structure was recorded by Garman (Proc. U. S. nat. Mus., *8*, 1885: 41).
106. Ann. Mus. Hist. nat. Paris, *4*, 1804: 201, 210, pl. 55, fig. 2.
107. Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 269.

Range. Western tropical Atlantic from southern Caribbean to Florida in coastwise waters, occasionally to North Carolina.

Details of Occurrence. U. jamaicensis has been reported often enough from Trinidad, Santo Domingo and Haiti, Jamaica, Cuba, and the Bahamas, to prove it widespread throughout the Caribbean-West Indian region. This may be equally true of it in the southern part of the Gulf of Mexico, though the only published record for it there is from Progresso, Yucatan. To the northward it occurs rather commonly among the Florida Keys and along both coasts of southern Florida.[108] But its regular range appears to extend little, if any, beyond middle Florida, for the only positive record of it farther north is of a single specimen taken near Cape Lookout, North Carolina, in June 1911.[109]

The published record, taken at face value, would suggest that this little Ray is wholly absent from the northern and western parts of the Gulf of Mexico. But its distribution elsewhere suggests that it will be found eventually all along the coast of Mexico in suitable situations, and perhaps along southern Texas as well.

It seems likely that it ranges eastward and southward along the South American Coast considerably beyond Trinidad, the farthest station in that direction where its presence has been actually reported, for there is no apparent thermal barrier to the southward dispersal of this or any other tropical Ray along South America short of the annual mean location of the isotherm for about 25° C (77° F) off mid-Brazil at about Lat. 20° S.

Synonyms and References:

Trygon jamaicensis Cuvier, Règne Anim., *2*, 1817: 137, footnote (Jamaica, ident. by ref. to Pastinaca marina, ferruginea, tuberculata Sloane [Hist. Jamaica, *2*, 1725: pl. 246, fig. 1, Jamaica]); Règne Anim., *2*, 1829: 400 (reprint of Cuvier 1817).

Trygonobatus torpedinus Desmarest, Prém. Decade Ichthyol., 1823: 6, pl. 1, fig. 1; also, Mém. Soc. Linn. Paris, *2*, 1823: 166 (descr., color, Cuba, ill. not seen); Bory de St. Vincent, Dict. Class Hist. Nat., *14*, 1828: 449; Atlas, 1831: pl. 116 (descr., ill. after Desmarest, 1823; Havana, Cuba); Gray, List Fish. Brit. Mus., 1, 1851: 125 (listed, Cuba).

Raia sloani Bancroft, Zool. J., *5*, 1830: 83 (listed, Jamaica).

Urolophus torpedinus Müller and Henle, Plagiost., 1841: 173, pl. 56, fig. 1 (descr., meas., ill., St. Domingo and Cuba); Poey, Memorias, *2*, 1858: 360 (listed, Cuba); Duméril, Hist. Nat. Poiss., *1*, 1865: 628 (descr., color, Haiti, Cuba specimens, type included); Garman, Proc. U. S. nat. Mus., *8*, 1885: 41 (descr. embryo, but local. "New Jersey" probably erroneous); Lönnberg, Öfvers. Svensk. Vet. Akad. Forh., *51*, 1895: 112 (listed, Key West and old Florida records); Duerden, J. Inst. Jamaica, *2* (2), 1895: 166 (no. tail spines, Jamaica); J. Inst. Jamaica, *2* (6), 1899: 614 (listed, Jamaica).

Urolophus torpedinus (in part) Günther, Cat. Fish. Brit. Mus., *8*, 1870: 485 (listed, W. Indies, Jamaica, but *U. halleri* Cooper 1863 and *U. mundus* Gill 1863, of Pacific Coast of Central America, included in synonymy); Werner, Zool. Jb., Syst. Abt. *21*, 1904: 301 (color, Jamaica, but California specimen also included).

Urolophus jamaicensis Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 81 (descr., W. Indies; New Jersey doubtful); Rep. U. S. Comm. Fish. (1895), 1896: 223 (listed as above); Jordan and Rutter, Proc. Acad. nat. Sci. Philad., [49], 1897: 93 (listed, Jamaica); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 49 (listed, Key West, Florida, by ref. to Lönnberg, 1894); Bean, B. A., Bahama

108. Recorded from Punta Gorda, Tortugas, Key West, the vicinity of Key Largo, Biscayne Bay, and Miami.

109. An embryo of this species, described many years ago by Garman (Proc. U. S. nat. Mus., *8*, 1885: 41, as *U. torpedinus* Desmarest), was reported from New Jersey. But this is so far beyond the normal limits of the range of this species that the specimen in question probably came from some more southern locality.

Is., Geogr. Soc. Baltimore, 1905: 296 (listed, Nassau, Bahamas); Cole and Barbour, Bull. Mus. comp. Zool Harv., *50*, 1906: 155 (listed, Progresso, Yucatán); Fowler, Rep. N. J. Mus. (1905), 1906: 76 (listed, New Jersey by ref. to Garman, 1885); Rep. N. J. Mus. (1906), 1907: 261 (name only), pl. 78 (ill. with two tail spines, no local.); Proc. Acad. nat. Sci. Philad., *62*, 1910: 473 (listed, Florida, Cuba); Rosen, Acta Univ. lund., N. S., Afd. 2, 7 (5) (Fysiog. Sällsk. Handl., N. S. *22* [5]), 1911: 47 (nos. young, size, Andros I., Bahamas); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 103 (range); Gudger, J. Elisha Mitchell sci. Soc., *28*, 1913: 160 (listed, C. Lookout, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 93 (listed, C. Lookout, N. Carolina, same specimen as Gudger, 1913); Mowbray, Bull. N.Y. zool. Soc., *26*, 1923: 93 (young born in New York Aquarium, from Florida); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 433, 456 (listed, Bahamas; Jamaica); Notul. Nat. Acad. nat. Sci. Philad., 181, 1946: 1 (color, Nassau, Bahamas).

Urolophus jamaicensis (in part) Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 81 (W. Indies by earlier refs., but S. Pedro, California specimen doubtless *U. halleri*).

Urobatis sloani[110] Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 402, pl. 28, pl. 53, fig. 3, pl. 69, figs. 4–5 (descr., ills., color, skel., Haiti); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 276 (descr., teeth, denticles, after Garman, 1913, C. Lookout, N. Carolina, by ref. to Coles, 1915); Fowler, Proc. biol. Soc. Wash., *36*, 1923: 28 (listed, Miami, Florida); Beebe and Tee-Van, Zoologica N.Y., *10*, 1928: 30 (descr., meas., size, ill., habits, stom. contents, capture, nos., Haiti); Fowler, Proc. Acad. nat. Sci. Philad., *80*, 1928: 456 (listed, Haiti); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 34 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 18 (diagn.); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 29 (listed, W. Indies northward, doubtfully New Jersey); Hildebrand, Copeia, 1941: 222 (listed, C. Lookout, N. Carolina); Longley and Hildebrand, Carneg. Inst., Pap. Tortugas Lab., *34*, 1941: 4 (size, Tortugas, Florida).

Urobatis vermiculatus (var. nov.) Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 402, pl. 29 (color, ill., Progresso, Yucatán).

Urobatis jamaicensis Fowler, Proc. biol. Soc. Wash., *33*, 1920: 146 (New Jersey by ref. to Garman, 1885, but probably erroneous); Borodin, Bull. Vanderbilt Oceanogr. (Mar.) Mus., *1* (4), 1934: 107 (listed, Jamaica); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 265 (size, Florida).

Urotrygon jamaicensis Breder, Bull. Bingham oceanogr. Coll., *1* (1), 1927: 6 (listed, no local.).

Urobatis vermiculatus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 29 (listed, Progresso, Yucatán).

Doubtful Synonym:

Leiobatus sloani Blainville, Bull. Soc. philom. Paris, 1816: 121 (name only, ref. perhaps to Pastinaca marina, ferruginea, tuberculata, Sloane [Hist. Jamaica, *2*, 1725: pl. 246, fig. 1]; see p. 427, footnote 110).

Genus *Urotrygon* Gill 1863

Urotrygon Gill, Proc. Acad. nat. Sci. Philad., 1863: 173; type species, *U. mundus* Gill. West coast of Central America.

Generic Synonyms:

Urolophus Günther, Proc. zool. Soc. Lond., 1871: 653, for *U. chilensis* Günther, Chile; Jordan and Gilbert, Bull. U. S. Fish Comm., *1*, 1882: 306, 307, for *U. aspidurus* Jordan and Gilbert, Panama Bay; Proc. U. S. nat. Mus., *5*, 1883: 579, for *U. asterias* Jordan and Gilbert, Mazatlan, Mexico, and Panama; Jordan and Bollman, Proc. U. S. nat. Mus., *12*, 1890: 151, for *U. goodei* Jordan and Bollmann, off Panama.

Generic Characters. Tail from center of cloaca a little longer than from center of cloaca to tip of snout. Caudal fin not more than $^1/_6$ as broad as long. Characters otherwise as in *Urolophus*.

110. The specific name *sloani* was first used by Blainville (Bull. Soc. philom. Paris, 1816: 121), but without any description or indication as to whether or not it referred to the Pastinaca marina, ferruginea, of Sloane, 1725, as

Range. Off west coast of North, Central and South America, Gulf of California to Chile in the Pacific; equatorial Brazil in the Atlantic.

Species. Six representatives of the genus from the Pacific Coast of America have been given separate specific names. But it is still to be determined whether all of these actually represent distinct species.[111] Two species have been described from the western Atlantic and Caribbean. One of these, *U. microphthalmum* Delsman 1941, appears to differ from all Pacific forms in its relatively much longer snout (p. 428). The other, *U. venezuelae* Schultz 1949, resembles *U. asterias* (Jordan and Gilbert) 1883 of the Pacific coasts of Mexico and Panama in general but differs from it in the less regular arrangement and smaller size of the spines along the mid-dorsal line of the disc, and in a relatively smaller eye (p. 432).

Key to Western Atlantic Species

1 a. Snout in front of eyes about $^1/_3$ as long as breadth of disc. Upper surface of disc naked. *microphthalmum* Delsman 1941, p. 428.

1 b. Snout in front of eyes only about $^1/_4$ as long as breadth of disc. Upper surface mostly prickly on disc and with a median row of slightly larger spines on disc and on anterior part of tail. *venezuelae* Schultz 1949, p. 430.

Urotrygon microphthalmum Delsman 1941

Figure 101

Study Material. None.

Distinctive Characters. The only western Atlantic Rays with which *Urotrygon microphthalmum* might be confused are *Urotrygon venezuelae* and *Urolophus jamaicensis.* A longer snout and naked disc (see Key, p. 428) set it apart from *U. venezuelae.* It differs from *Urolophus jamaicensis* in the facts that: the contour of its disc is definitely angular in front, with pointed snout and nearly straight anterior margins; its snout in front of eyes is about twice as long as the distance between the eyes (only about as long as the distance between the eyes in *Urolophus jamaicensis*); its pectorals are angular in outline; its caudal fin is narrower relatively; and its tail, from center of cloaca to tip, is considerably longer than the distance from center of cloaca to tip of snout (shorter than distance to snout in *Urolophus jamaicensis*).

Description.[112] Disc about as broad as long or a little longer, its anterior contour angular; anterior margins nearly straight; posterior margins rather strongly convex; outer and posterior corners well rounded; tip of snout pointed, projecting a little; anterior angle in front of spiracles about 100°. Tail strongly depressed dorsoventrally

seems probable. It was a *nomen nudum,* therefore, and it so continued until it was revived (with description) by Garman in 1913.

111. For a recent survey of these Pacific species, see Beebe and Tee-Van (Zoologica N. Y., *26,* 1941: 264, and footnote), who remark "the species of eastern tropical *Urotrygon* are poorly known from a small number of specimens, and in those species where a larger number of specimens have been taken, there is considerable variation."

112. After Delsman (Mém. Mus. Hist. nat. Belg., [2] *3* Fasc. 21, 1941: 65, 66, fig. 8).

at base, with low lateral keel on each side; its length from center of cloaca about 1.2 times as great as distance from center of cloaca to tip of snout.

A single tail spine, serrate along distal part; its extreme length nearly as great as length of snout in front of eyes; its origin a little less than halfway (about 42 %) back from level of axils of pectorals toward tip of tail.

Skin, apart from tail spine, smooth throughout.

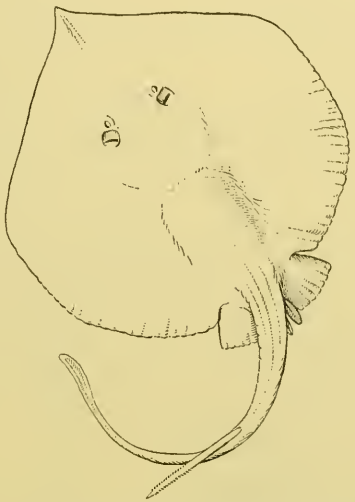

FIGURE 101. *Urotrygon microphthalmum*, juvenile male, 220 mm broad, from off the Amazon River; after Delsman.

Snout in front of eyes about 2.2 times as long as distance between eyes. Eye noticeably minute, much smaller than spiracle. Spiracles close behind eyes, their length about $^1/_3$ as great as distance between eyes. Nasal curtain fringed. Mouth slightly arched.

Teeth small, pointed.

Caudal fin much narrower relatively than in *Urolophus jamaicensis* (cf. Fig. 101 with 99), its upper and lower origins indefinite; lower about even with upper, posterior to tip of tail spine by a distance a little more than half as great as distance between eyes. Pelvics reaching rearward beyond posterior limits of pectorals for a distance about as great as distance between eyes, their anterior margins nearly straight, posterior margins weakly convex; outer and posterior corners angular, a little less than 90°. Claspers of mature male not seen.

Color. Upper surface gray. Lower surface whitish, the disc edged with gray.

Size. The claspers on the largest specimen seen, 220 mm long by 103 mm broad, were still small (Fig. 101). The size at maturity is not known.

Developmental Stages. Embryos have not been seen.

Habits. The two specimens taken so far were from a depth of 20–30 fathoms on muddy bottom.

Range. Known only from the mouth of the Amazon, Lat. 1° 06′ N, Long. 47° 53′ W.

Reference:

Urotrygon microphthalmum Delsman, Mém. Mus. Hist. nat. Belg., (2) *3* Fasc. 21, 1941: 65, 66, fig. 8 (descr., ill., mouth of Amazon).

Urotrygon venezuelae Schultz 1949

Figure 101 α

Study Material. Female (type), 255 mm long, from Gulf of Venezuela (U.S.Nat. Mus., No. 121966).

Distinctive Characters. This species could hardly be confused with any other western Atlantic Ray, except for *U. microphthalmum* (p. 428) or *Urolophus jamaicensis* (p. 420). It is separable from the first of these by its generally prickly back (smooth on *microphthalmum*) with a median row of slightly larger spines from the nuchal region rearward along disc and anterior part of tail. The readiest field mark to separate it from *Urolophus jamaicensis* is that its tail from center of cloaca is somewhat longer than the distance from center of cloaca to tip of snout (shorter in *Urolophus jamaicensis*), and its disc is considerably wider relatively, with the tip of snout more prominent (cf. Fig. 101 α with 99).

Description. Proportional dimensions in per cent of total length. Female, type, 255 mm long, from Gulf of Venezuela (U.S.Nat. Mus., No. 121966).

Disc: extreme breadth 54.2; vertical length 47.6.
Snout length: in front of orbits 12.8; in front of mouth 12.8.
Orbits: horizontal diameter 2.5; distance between 6.2.
Spiracles: length 3.3; distance between 7.2.
Mouth: breadth 5.8.
Exposed nostrils: distance between inner ends 6.0.
Gill openings: lengths, 1st 2.4; 3rd 2.4; 5th 1.4; distance between inner ends, 1st 12.2; 5th 8.0.
Pelvics: length of anterior margin 9.8.
Distance: from tip of snout to center of cloaca 46.2; from center of cloaca to origin of tail spine 24.3; to tip of tail 53.8.

Disc about 1.1 times as broad as long; space between orbits slightly concave transversely; snout pointed, projecting rather noticeably; outlines concave close behind tip of snout, thence broadly and uniformly convex to rear corners, the latter more abruptly rounded; inner margins short and weakly convex. Axis of greatest breadth

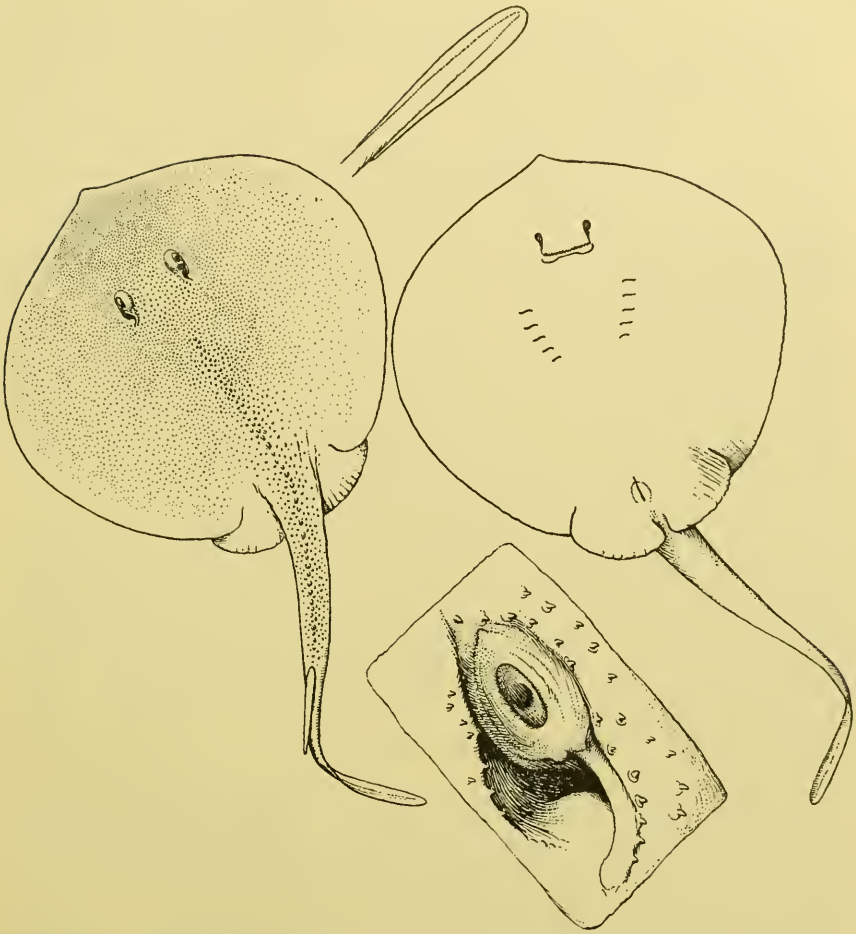

FIGURE 101α. *Urotrygon venezuelae*, holotype, female, 255 mm long from Gulf of Venezuela (U. S. Nat. Mus., No. 121966). Upper and lower surfaces. Tip of tail, 1.3×; eye and spiracle, 3.8×.

about 50 % of distance back from tip of snout toward rear limits of disc. Tail from center of cloaca about 1.16 times as long as distance from center of cloaca to tip of snout; breadth at base about equal to distance between spiracles; tapering evenly rearward to base of spine where it narrows more abruptly and becomes thin transversely approaching caudal fin.

One tail spine, its origin posterior to center of cloaca by a distance about as great as distance from tip of snout to level of fourth pair of gill openings; its length nearly as great as length of snout in front of eyes.

Back naked along posterior margins of pectorals but roughened elsewhere on disc and tail with small prickles, those anterior to eyes sharp-pointed and set so close together that bases are in contact; those elsewhere on disc more loosely spaced and mostly blunt-tipped or rounded; mid-dorsal line from nuchal region to tail spine with an irregular row of about 45 blunt spines a little larger than the prickles elsewhere on disc and tail; mid-dorsal spines on tail slightly larger than those on disc; sides of tail prickly to tip; upper caudal lobe prickly, but lower lobe smooth; pelvics and skin over eyes smooth. Lower surface smooth.

Snout in front of eyes about 2.1 times as long as distance between inner margins of orbits and about 5.1 times as long as eye. Eye about 40 % as long as distance between orbits. Spiracles close behind orbits and about 1.3 times as long. First gill openings about $^2/_5$ as long as breadth of mouth; fifth gill openings about 60 % as long as first; distance between inner ends of first gill openings about as long as snout in front of eyes and about twice as long as breadth of mouth; distance between inner ends of fifth gill openings about $^2/_3$ as long as distance between first gills.

Teeth $\frac{34}{30}$, ovoid, without definite cusp, close-set in quincunx.

Caudal fin about $^1/_6$ as broad as long, with rounded tip; origins of upper and lower sides opposite. Pelvics with nearly straight anterior margin, weakly convex distal margin, and rather abruptly rounded corners; anterior margin about $^5/_7$ as long as distance from origin to rear corner, the latter reaching rearward from level of rear limits of pectorals for a distance about half the length of snout in front of eyes or about $^1/_3$ of distance from level of rear corners of pectorals toward origin of tail spine.

Color. Plain greyish brown above, without markings but seemingly faded (in alcohol); cream-colored below.

Size. The length of the only specimen seen (255 mm) gives no clue as to the size this species may reach at maturity.

Relationship to Extralimital Species. This Ray, as remarked by its discoverer,[113] appears to be the Atlantic representative of *U. asterias* (Jordan and Gilbert) 1883 of the Pacific coasts of Mexico and Panama, which, alone among eastern Pacific representatives of the genus, has a generally prickly back with a continuous row of somewhat larger spines along the mid-dorsal line.[114] But *U. venezuelae* differs from *U. asterias* in that its mid-dorsal spines are only a little larger than the prickles elsewhere on the back (much larger and more prominent in *asterias*), and that its eye is smaller relative to the length of the snout.[115]

113. Schultz, Proc. U. S. nat. Mus., *99*, 1949: 26.

114. See Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 264–268) for a recent survey of eastern Pacific species of *Urotrygon*.

115. Snout, anterior to eyes, about five times as long as eye in *U. venezuelae*, not more than four times on the type specimen of *U. asterias* (Schultz, Proc. U. S. nat. Mus., *99*, 1949: 26, table I).

Range. So far known only from a single specimen, collected by the USS NIAGARA in the Gulf of Venezuela at Point Macolla, April 19, 1925.

Reference:

Urotrygon venezuelae Schultz, Proc. U. S. nat. Mus., 99, 1949: 24 (descr., meas., ill., Gulf of Venezuela).

Family MYLIOBATIDAE

Eagle Rays

Characters. Myliobatoidea with pectorals either narrow opposite eyes or entirely interrupted there, the head thus being conspicuously marked off from the body. Anterior subdivisions of pectorals united across front of head below tip of snout, forming a single subrostral lobe. Anterior contour of cranium nearly straight centrally, rounded at outer corners. Crown conspicuously elevated. Tail much longer than disc, slender, armed with a serrate spine (or spines) in some species but not in others. A small dorsal fin on anterior part of tail, but no caudal fin. Eyes and spiracles on sides of head.[1] Nasal curtain with fringed margin, roofing over all but outermost ends of nasal apertures. Mouth on ventral surface; transverse curtain on roof of mouth coarsely fringed; fold overlapping youngest rows of teeth with or without transverse rows of papillae, its free anterior margin thick and fleshy, either nearly smooth or bordered with low blunt knobs. Floor of mouth posterior to dental plate with several papillae. Gill openings little if any longer than eye. Teeth in 1–7 series only, flat and pavement-like, the median series much the largest if there be more than one series; several rows in function simultaneously. Skin naked except for tail spine (or spines), or with tubercles around orbits and along midline of back on males. Pelvis more or less strongly arched, with shorter or longer median process, directed forward, but without lateral processes.[2] Anterior and posterior surfaces of gill arches, inward from gill filaments, each with a series of fleshy knobs or papillae widely spaced. No electric organs. Characters otherwise as in the Dasyatidae (p. 335).

Remarks. The tail spines of such myliobatids as possess them are venomous, to judge from the clinical effects of wounds by the Spotted Eagle Rays (*Aetobatus*), the only genus for which information is at hand (p. 461).

Size. Fully grown specimens of different species range up to at least seven to eight feet (p. 459) in breadth and perhaps somewhat larger. They have been credited with weighing up to 800 pounds, and Eagle Rays are much heavier than dasyatid Rays of equal dimensions because of the greater thickness of their pectorals. However, we suspect that estimated weights of large specimens are apt to be considerably exaggerated, since these Rays are awkward to handle because of their shape.

Development. It has been known for many years that Eagle Rays are ovoviviparous. As in the Dasyatidae, the embryos are nourished by a creamy fluid secreted by vascular

1. On the dorsal surface in the Dasyatidae, Urolophidae, and Gymnuridae.
2. For illustrations of the pelvis, see Fig. 79.

villi that clothe the walls of the maternal uterus. This fluid is taken in through the embryonic spiracles and mouth, and probably it is absorbed by the external embryonic gill filaments as well, so long as these persist. By the time the embryos have lost their external gills and have absorbed the yolk sac, they already approach their parents in general form and proportions; their subrostral fins already project more or less beyond the front of the cranium, the posterior margin of the nasal curtain is fringed,[3] the tooth pattern is at least forecast, and the color pattern is established.

Range. Tropical to temperate latitudes of all three great oceans, including the Mediterranean Sea, both in continental waters and around the larger offlying islands and island groups. Southwest Africa to southern England, Scotland, and (rarely) southern Norway in the eastern Atlantic; northern Argentina to southern New England in the western Atlantic.

Genera. The members of the family fall into four groups (see Key, p. 434), depending on the following characters: one series of teeth in each jaw or more than three series; rostral sectors of the pectorals connected or not with the main portions of the fins by a continuous series of cartilaginous rays along the sides of the head; and tail armed or not with a spine (or spines). Thus, the taxonomic picture is a simple one so far as generic divisions are concerned. But the generic nomenclature within the family has been confused by uncertainty as to the authorships and dates (and hence as to type species) that are to be assigned to the genera *Myliobatis* and *Aetobatus*,[4] which were the earliest names proposed for any members of the family when separated from the old Linnean genus *Raja*.

In applying the name *Myliobatis* Cuvier 1817 to members of the family with more than three series of teeth and with the rostral portions of the pectorals united with the chief portions of the fins along the sides of the head, we follow Garman[5] rather than Fowler,[6] who applied it to those with several series of teeth but with the pectorals entirely interrupted.

Key to Genera

1a. Only a single series of teeth in each jaw. *Aetobatus* Blainville 1816, p. 451.

3. See p. 459 for *Aetobatus narinari*; see also Southwell and Prashad (Rec. Indian Mus., *16*, 1919: 233, pl. 19, figs. 4, 4a) for an account and illustrations of the embryos of *Aetomylaeus nichofii* (Bloch and Schneider) 1801, of the western Pacific-Australia area, East Indian region, and Indian Ocean.

4. *Aetobatus* Blainville 1816 (Bull. Soc. philom. Paris, 1816: 112) properly applies to myliobatids with only one series of teeth, since the 11 species that Blainville mentioned by name included *narinari* (doubtless the *Raja narinari* of Euphrasen 1790), which was designated as type species by Gill (Proc. U. S. nat. Mus., *17*, 1894: 111). *Myliobatis* Cuvier 1817, type species *Raja aquila* Linnaeus 1758, with several series of teeth and pectorals continuous along the sides of the head, appears to antedate *Myliobatis* G. St.-Hilaire, type species *M. bovina* St.-Hilaire, with pectorals entirely interrupted along sides of head (designated by Fowler, Bull. geol. Surv. N. J., *4*, 1911: 84). Although the title page of the volume that contains St.-Hilaire's account of *Myliobatis* (Savigny, Zool. Egypte, *1*) is dated 1809, the plate in question appeared in 1817 (according to Isidore G. St.-Hilaire, Vie, Travaux . . . Etienne Geoffrey St.-Hilaire, 1847: 425), and the pages in question (Poiss. Mer Rouge, pp. 323, 334) were not printed until about 1827 (Sherborn, Proc. zool. Soc. Lond., 1897: 386). *Aetobatis* Blainville 1825 (in Vieillot, Faune Franç., Poiss., 1825: 38) clearly is a synonym of *Myliobatis* Cuvier 1817, since its type (and only included) species was the same. But *Aetobatis* Müller and Henle 1841 is equivalent to *Aetobatus* Blainville 1816, as is *Stoasodon* Cantor 1849 (Malay. Fish., J. roy. Asiatic Soc., *18*, 1849: 1416).

5. Mem. Harv. Mus. comp. Zool., *36*, 1913: 428.

6. Bull. U. S. nat. Mus., 100 (*13*), 1941: 469.

1b. Normally seven series of teeth in each jaw.

2a. Rostral portion of pectorals (subrostral fin) connected with main portions of fins by a continuous series of radial cartilages extending along sides of head. *Myliobatis* Cuvier 1817, p. 435.

2b. Rostral portion of pectorals (subrostral fin) entirely separated from main portions of fins along sides of head.

3a. Tail armed with a serrate spine (or spines). *Pteromylaeus* Garman 1913. Tropical to warm temperate eastern Atlantic, including Mediterranean; South Africa; Melanesia, Queensland and New South Wales.

3b. Tail not armed with a serrate spine.

Aetomyleus Garman 1908. Western Pacific from southeastern Australia (near Melbourne) to Japan, including Cochin-China and the China Sea; Philippines; East Indies; Malay Peninsula; coasts of Burma and India; Ceylon; Red Sea.

Genus *Myliobatis* Cuvier 1817

Myliobatis Cuvier, Règne Anim., *2*, 1817: 137; type species, *Raja aquila* Linnaeus (Syst. Nat., *1*, 1758: 232), designated by Jordan and Gilbert (Bull. U. S. nat. Mus., 16, 1883: 50).

Generic Synonyms:

Myliobates Cuvier, Thierreich (German transl. by Schinz), *2* (19), 1822: 234; emended spelling for *Myliobatis* Cuvier 1817.

Aetobatis Blainville, in Vieillot, Faune Franç., 1825: 38; type and only included species, *Raja aquila* Linnaeus 1758.

Pastinaca (in part) Gray, Cat. Fish. Coll. and Descr. by L. T. Gronow in Brit. Mus., 1854: 12; includes *Raja aquila* Linnaeus 1758.

Holorhinus Gill, Proc. Acad. nat. Sci. Philad., 1862: 331; type and only included species, *Rhinoptera vespertilio* Girard (Proc. Acad. nat. Sci. Philad., *8*, 1856: 137; Boston J. nat. Hist., *6*, 1857: 544, pl. 26); California. Not *Myliobatis vespertilio* Bleeker (Verh. batavia Genoot., *24*, 1852: Plagiost., 85), Dutch East-Indies, which falls in the genus *Aetomyleus* Garman 1908, as here defined (p. 435).

Miliobatis Salvadori, Boll. Mus. Zool. Anat. comp. Torino, *3*, 1888: 23; equals *Myliobatis* Cuvier 1817.

Aetobatus (in part) McCulloch, Biol. Result. F. I. S. Endeavour, *1*, 1911: 15; including *Myliobatis australis* MacLeay (Proc. Linn. Soc. N. S. W., *6*, 1881: 380), Australia; Beebe and Tee-Van (Zoologica N.Y., *26*, 1941: 271); also including *Myliobatis californicus* Gill 1865 and *M. peruvianus* Garman 1913.

Leiobatus Lahille, Physis B. Aires, *5*, 1921: 63; including *Raja aquila* Linnaeus 1758.

Not *Leiobatus* Rafinesque, Carratt. Gen. Spec. Sicil., 1810: 16; equals *Rhinobatos* Link 1790, which see, p. 50.

Not *Aetobatus* Blainville, Bull. Soc. philom. Paris, 1816: 112, which see, p. 451.

Not *Myliobatis*, G. St.-Hilaire, 1817, 1827; see p. 434, footnote 4.

Generic Characters. Disc lozenge-shaped, broader than long. Tail much longer than body, with one or more serrate spear-tipped spines close behind dorsal fin; tail spine similar in structure to those of the Dasyatidae (p. 335) and probably similarly venomous.[7] Dorsal fin originating opposite tips of pelvics or posterior to them. Free posterior

7. See Halstead and Modglin (Copeia, 1950: 165–175) for detailed account of the anatomy of the tail spines of the Californian *Myliobatis californicus*.

edge of transverse curtain on roof of mouth straight, coarsely fringed; free anterior margin of fold overlapping youngest row of teeth is bordered with a band of short blunt knobs but without papillae farther back; floor of mouth with 5–6 slender papillae. Teeth in seven series above and below, those of successive rows closely apposed but not overlapping, forming a single dental plate in each jaw; upper dental plate strongly bowed downward anteriorly, but the lower nearly straight from front to rear; the median series of teeth broader than the lateral series. Skin, apart from tail spines, smooth or with a tubercle over the eye, or with a few low tubercles in midline of back, also on shoulder region in males. Subrostral fin connected with main portions of pectorals by a continuous series of radial cartilages along each side of head; those supporting main portion of pectorals little if any stouter than those of subrostral fin. Pelvis strongly arched, with a long slender median process directed forward. Anterior and posterior surfaces of gill arches, inward from gill filaments, each with a longitudinal series of low rounded fleshy knobs, widely spaced. Characters otherwise those of the family.

Size and Development. The larger species grow to a width of at least four feet, perhaps wider, and to a length of 15 feet or more including the tail.

Development is ovoviviparous, and the uterus is described as lined with villi,[8] as it is in the Sting and Butterfly Rays and in other Eagle Rays (pp. 337, 397, 433).

Habits. The true Eagle Rays seem to fly through the water rather than swim in the conventional sense of the word, doing so both gracefully and fairly rapidly. "On occasions they will break the surface of the sea and skim for a short distance through the air. When captured, they are unpleasant customers to handle, lashing about in all directions with the flexible tail and trying to bring the saw-edged spine into action."[9] One kept in an aquarium was described as grunting rather loudly whenever it was taken out of the water.[10]

The presence of Eagle Rays of this genus in the vicinity of offlying islands, such as Madagascar and Reunion in the Indian Ocean and the Canaries and Azores in the Atlantic, and their reported capture 320 miles off Plymouth, England,[11] is evidence that they may carry out journeys of considerable length across the open sea. But they are most often encountered in coastal waters. Within their centers of abundance they occur commonly in shallow bays and estuarine situations over sand and mud flats.

Although a species of *Myliobatis* has been reported from an Argentine lagoon that is connected with the sea by only a narrow canal,[12] inclusion of the genus in lists of freshwater fishes[13] seems premature; so far as we can learn, this leads back to a specimen from Rio de la Plata,[14] which seems likely to have been taken in the vicinity of Buenos Aires (having been received by the British Museum from a correspondent in that city) and hence from salt water.

8. Alcock, J. Asiat. Soc. Beng., *59* (2), 1890: 51; Alcock and Wood-Mason, Proc. roy. Soc. Lond., *50*, 1891: 202; Gudger, Proc. biol. Soc. Wash., *26*, 1913: 101.
9. Norman and Fraser, Giant Fishes, 1937: 77.
10. Moreau, Poiss. France, *1*, 1881: 446.
11. Jenkins, Fish. Brit. Isles, 1925: 342.
12. McDonagh (Rev. Mus. La Plata, *34*, 1934: 95, footnote 1), as *M. aquila.*
13. As by Eigenmann (Rep. Princeton Exped. Patagonia, *3* [1], 1909: 348; *3* [2], 1909: 378) and by Smith (Biol. Rev. [Cambridge], *11*, 1936: 65).
14. Günther, Ann. Mag. nat. Hist., (5) *6*, 1880: 8.

Eagle Rays of this genus appear to feed exclusively on the bottom, chiefly if not entirely on the larger crustacea and on hard-shelled mollusks, both univalve and bivalve. They are described as swimming along the bottom until they encounter the currents of water expelled by the siphons of clams, which they dig out by flapping their pectoral fins and then crush with their millstone-like teeth. Indeed, they are so destructive to clam beds in San Francisco Bay, California, that the local species (*Myliobatis californicus*) is "the object of special exterminating parties by sport fishermen."[15] But neither of the western Atlantic species of the genus is plentiful enough to be a menace to shellfish beds.

Range. Rays of this genus are widely distributed in tropical to warm temperate continental waters; from northern Argentina to southern New England in the western Atlantic; from South and Southwest Africa to southern Great Britain, less commonly to Scotland, and occasionally to southern Norway, in the eastern Atlantic, including the Canaries, the Azores, and the Mediterranean; the Indian Ocean in general from Bay of Bengal[16] south to Madagascar, Reunion, and South Africa; Australia, Tasmania, and New Zealand; the western Pacific north to Japan and Korea; the west coast of North America from northern California (Cape Mendocino) southward to Lower California; also Peru, and perhaps Chile.

No representative of the genus, as defined here, has been recorded from the East Indies, so far as we can learn, or from any of the island groups of the middle or western tropical Pacific. But it is more probable that they have been overlooked in these waters than that their range fails to include them. The bathymetric range actually recorded thus far for *Myliobatis* extends from the surface down to about 60 fathoms.

Species. Recent surveys of the genus, as here defined,[17] recognize three species in the Atlantic and seven or eight in the Pacific and Indian oceans, besides one problematical form, described as lacking a dorsal fin,[18] which has never been seen since it was first recorded.

The three Atlantic species, *M. aquila* (Linnaeus) 1758 of the eastern side, *M. freminvillii* Lesueur 1824 and *M. goodei* Garman 1885 of the western side, form an extremely homogeneous group. But our own examination of the specimens listed elsewhere has convinced us that the two American forms are separable by the various differences stated under Distinctive Characters given for each (pp. 439, 446). Minor differences also appear to separate both members of this pair from *M. aquila* (see Key to Species, p. 438). But final decision on this point must await comparison (especially of *M. goodei*) with more extensive series from the eastern Atlantic[19] than we have seen.

M. californicus Gill 1865 from California and Mexico parallels *M. freminvillii* in the position of the dorsal fin close behind the rear limits of the pelvics, but it resembles *M. goodei* and *M. aquila* more nearly in the small size of its dorsal and in the shortness

15. Walford, Fish Bull. Sacramento, 45, 1935: 61.
16. Jenkins (Fish. Brit. Isles, 1925: 342) reports taking *Myliobatis* frequently in the Bay of Bengal.
17. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 428; Fowler, Bull. U. S. nat. Mus., 100 (13), 1941: 458, as *Holorhinus*.
18. *Myliobatis rhombus* Basilewsky, Nouv. Mém. Soc. nat. Moscow, *10*, 1855: 250; Pekin.
19. We have seen only two small specimens of *M. aquila*.

of its rostral fin, and it differs from all three Atlantic species in the greater length of the inner margins of its pectorals from axil to rear corner.[20] A second Pacific-American form (*M. peruvianus* Garman 1913), so far known only from Peru, may eventually prove to fall within the limits of variation of *M. goodei*, which it resembles closely in the shape of the posterior pectoral corners, in the position and size of the dorsal fin, in its proportionate dimensions in general, including the breadth between the gill openings of the posterior pairs,[21] and in its teeth. The status of *M. chilensis* Philippi 1892 is problematical.[22]

Lacking adequate material, we are unable to judge how many good species are actually represented among those of the genus that have been named from the western Pacific and Indian oceans.[23]

Key to Atlantic Species

1a. Base of dorsal fin nearly or quite (90–100 %) as long as distance between exposed nostrils; its origin close behind rear limits of pelvics.
freminvillii Lesueur 1824, p. 438.

1b. Base of dorsal fin not more than $^2/_3$–$^3/_4$ (62–77 %) as long as distance between exposed nostrils; its origin posterior to rear limits of pelvics by a distance from 1–3 times as long as base of dorsal.

2a. Distance between inner ends of fifth gill openings more than 1.5 times as long as distance between exposed nostrils. *goodei* Garman 1885, p. 446.

2b. Distance between inner ends of fifth gill openings only about 1.2 times as long as distance between exposed nostrils.
aquila (Linnaeus) 1758.
Eastern Atlantic, including the Mediterranean; north commonly to northwestern France, less regularly to England and Scotland, and occasionally to southern Norway; also reported from Reunion I. in the southwestern Indian Ocean, and from the Natal Coast of South Africa.

Myliobatis freminvillii Lesueur 1824

Eagle Ray

Figures 102, 103

Study Material. Fifteen specimens, male and female, 170 to 860 mm wide, and two embryos, 140 and 144 mm wide, from: Rio de Janeiro; eastern shore of Virginia;

20. Inner margin of pectoral longer than distance between orbits on two *M. californicus*, 650 and 820 mm wide.
21. See Garman's illustration (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 36, fig. 5). For a recent account with references, see Hildebrand (Bull. U. S. nat. Mus., 189, 1946: 74) as *Aetobatus peruvianus*.
22. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 430) has pointed out that this name was based on an abnormal specimen, the relationship of which to other members of the genus cannot be determined from either the description or illustration (Philippi, An. Mus. nac. Chile, *1*, 1892: 6, pl. 3, fig. 1).
23. For a recent survey of these, including *M. aquila* (Linnaeus) 1758, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 459, as genus *Holorhinus*).

Ocean City, Maryland; Noank, Connecticut; Point Judith, Rhode Island; Woods Hole and Provincetown, Massachusetts; in collections of U.S. National Museum, Harvard Museum of Comparative Zoology, and U.S. Fish and Wildlife Service.

Distinctive Characters. Easily determinable features that separate *M. freminvillii* from its genus mate *M. goodei* of the western Atlantic, are: inner ends of fifth pair of

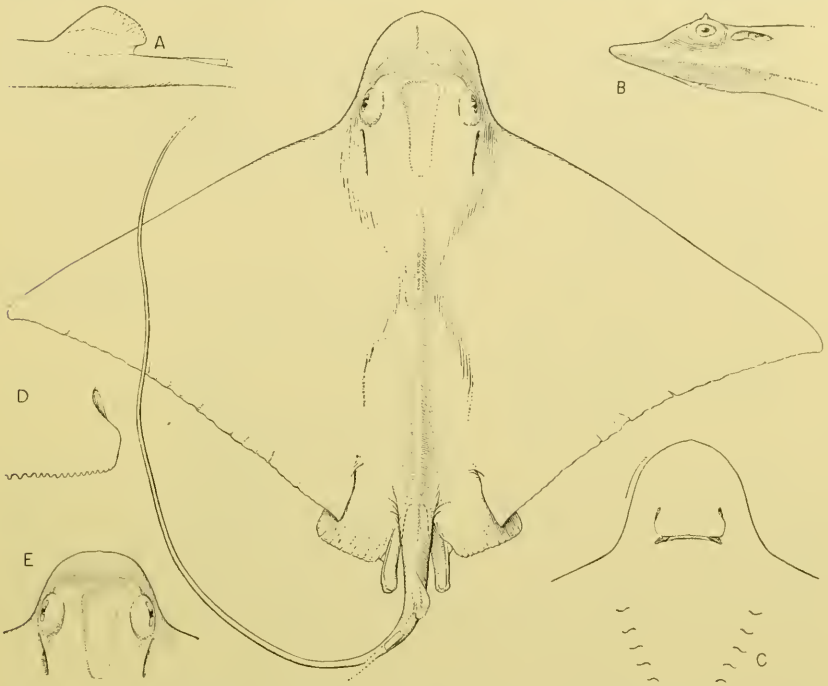

FIGURE 102. *Myliobatis freminvillii*, male, 761 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 396). *A* Side view of anterior part of tail to show dorsal fin, about 0.4×. *B* Side view of head. *C* Ventral view of head and gill area. *D* Margin of left-hand side of nasal curtain, about 0.5×. *E Myliobatis aquila*, 340 mm wide, from Mediterranean (Acad. Nat. Sci. Philad.).

gill openings only 1.0–1.2 times as far apart as distance between inner ends of nostrils (1.6–1.9 times in *M. goodei*); dorsal fin conspicuously larger in *M. freminvillii* relatively, its base 0.9–1.0 times as long as the distance between the nostrils (only 0.6–0.8 times in *M. goodei*); dorsal fin usually situated farther forward on tail in *M. freminvillii*, its origin about opposite rear limits of pelvics or only a little posterior thereto (ordinarily posterior to tips of pelvics by a distance 2–3 times as long as its own base in *M. goodei*); tips of pectorals narrower in *M. freminvillii* (cf. Fig. 102 with 104); and breadth between axils

of pectorals less than distance between inner ends of first pair of gill openings in *M. freminvillii* (as great or greater than distance between first gill openings in *M. goodei* of all sizes). Although the subrostral lobe averages longer in *M. freminvillii*,[24] there is no actual discontinuity between the two species in this respect in the one sex (female) for which comparison has been possible. Other differences between *M. freminvillii* and *M. goodei*, supposedly alternative, such as relative size of eye and of teeth[25] and breadth of pectoral flange below eye, have not proved so.

Description. Proportional dimensions in per cent of extreme breadth of disc. Female, 650 mm broad, from Provincetown, Massachusetts (Harv. Mus. Comp. Zool., No. 992). Male, 761 mm broad, from Rio de Janeiro (Harv. Mus. Comp. Zool., No. 396).

Disc: vertical length 57.3, 63.1.
Snout length: in front of orbits 7.2, 9.8; in front of mouth 10.3, 12.6.
Orbits: horizontal diameter 4.8, 5.0; distance between 9.8, 10.2.
Spiracles: length 5.5, 5.4; distance between 12.6, 12.6.
Mouth: breadth 8.3, 8.3.
Exposed nostrils: distance between inner ends 6.5, 7.0.
Gill openings: lengths, 1st 1.8, 1.8; 3rd 2.1, 2.1; 5th 1.2, 1.2; distance between inner ends, 1st 13.7, 14.5; 5th 7.8, 6.7.
Dorsal fin: vertical height 3.1, 3.0; length of base 6.1, 6.2.
Pelvics: outer margin 11.5, 13.2.
Distance: from tip of snout to center of cloaca 53.8, 57.8; from center of cloaca to origin of tail spine 18.8, 20.3; to tip of tail 124.0, 111.0.

Disc lozenge-shaped, its extreme breadth 1.6–1.8 times as great as length from tip of subrostral fin to rear limits of pectorals; anterior margins nearly straight or weakly convex; posterior margins weakly and uniformly concave; outer corners considerably narrower than in *M. goodei* (cf. Fig. 102 with 104); posterior corners an abrupt angle of about 80°; inner margins weakly convex, about as long as breadth of mouth. Axis of greatest breadth about 70 % of distance from tip of subrostral fin back toward axils of pectorals. Breadth between axils of pectorals less than distance between inner ends of first gill openings by a distance $^1/_4$–$^1/_2$ as great as that between exposed nostrils. Tail moderately stout anterior to spine, tapering thence rearward to whiplash tip; its length from center of cloaca as much as 2.3–2.5 times as great as length of disc to tip of rostral fin in small specimens, somewhat shorter relatively in large ones; usually more or less damaged.[26]

One or two tail spines, the anterior one the smaller (when there are two), hence evidently the more recently formed; the largest, when fully developed, about as long as distance between eyes; about 0.1 as broad where exposed at base as long; origin of

24. Subrostral fin, anterior to front of cranium, 0.9–1.2 times as long as distance between outer ends of nostrils in *M. freminvillii*; 0.7–1.0 times that long in female *M. goodei*.
25. Garman, Proc. U. S. nat. Mus., *8*, 1885: 39; Jordan and Evermann, Bull. U. S. nat. Mus., 47 (3), 1898: 2755.
26. In one specimen, 600 mm wide, from Woods Hole, the tail had been lost posterior to the spine and the wound was entirely healed over.

anterior spine (when there are two) posterior to axils of pelvics by a distance about as great as distance between eyes; lateral teeth directed strongly rearward and so close together as to form a nearly continuous cutting edge outwardly.

Skin, apart from tail spine, perfectly smooth on small specimens; but larger individuals of both sexes with a row of low oval tubercles along midline of back in shoulder

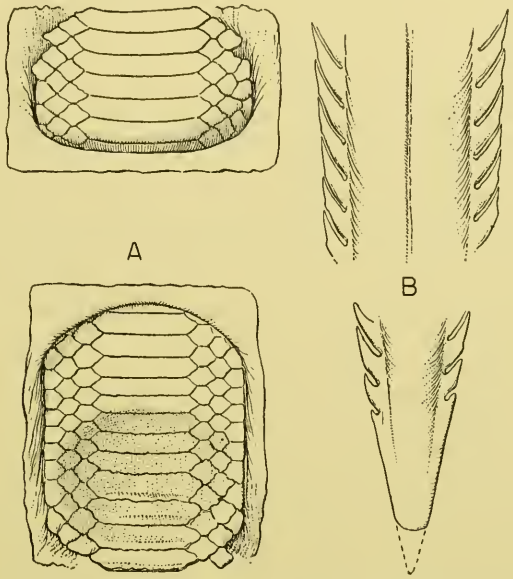

FIGURE 103. *Myliobatis freminvillii*. *A* Upper teeth (above) and lower teeth (below) of male, 705 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 400), about 1.9×. *B* Tip and middle part of tail spine of specimen from Woods Hole, Massachusetts (U. S. Nat. Mus., No. 22783), about 7×.

region, at first 3–4, finally 7–8; males at maturity also with one prominent conical tubercle on margin of orbit above eye, the tip alone emerging from the skin.

Median zone of upper surface of head conspicuously concave from forehead rearward to level of posterior ends of spiracles. Distance from level of front of orbits to front of subrostral fin about 0.7–0.8 as great as distance between orbits in females; 1.0–1.2 times in adult males. Orbits not prominent; about 50–62 % as long as distance between them. Spiracles much longer than broad, at about same level as orbits on sides of head, about twice (1.9–2.1 times) as long as horizontal diameter of eye and a little longer than orbits. Anterior margins of gill openings sinuous (Fig. 102 C); first to fourth

averaging a little shorter than diameter of eye; fifth gill openings only about $^2/_3$ as long as first to fourth; distance between inner ends of first gills about twice as great as distance between exposed nostrils; distance between inner ends of fifth gills about half (47–57 %) as great as distance between first gills. Free posterior margin of joint nasal curtain nearly straight, coarsely fringed with short rounded lobelets. Mouth nearly straight transversely, occupying about half of breadth of head. Floor of mouth, posterior to dental plate, with 5–6 blunt fleshy papillae; transverse curtain on roof of mouth with fringed margin.

Teeth normally in seven series both above and below, but occasional specimens with more or fewer; hexagonal; similar in general shape in the two jaws, but uppers weakly concave anteriorly and lowers nearly straight; those of median row about 3.5 times as broad (transversely) as long (anteroposteriorly) in upper jaw and 2.5 times as broad as long in lower jaw of young specimens, but increasing in relative breadth to about five times as broad (transversely) as long (anteroposteriorly) in both jaws of large individuals; teeth of the three lateral series on either side only about as broad as long; length of median teeth about $^1/_6$ as great as horizontal diameter of eye; about four rows of teeth exposed (i. e., in function) above and six below in small specimens, but about six rows exposed above (5–6 others concealed in roof of mouth) and 12–13 rows exposed below in adults.

Subrostral fin broadly rounded in females but more ovate in general form in adult males, its midpoint marked by a low protuberance. Minimum width of lateral continuation of pectoral along side of head about $^1/_6$–$^1/_4$ as great (opposite eye) as length of subrostral fin, thus averaging narrower than in *M. goodei*. Dorsal fin about half as high as the length of its base, its origin varying from about opposite rear tips of pelvics to posterior to them by a distance about $^1/_3$ as long as base of dorsal; anterior margin of dorsal nearly straight; posterior margin moderately convex toward apex but conspicuously indented toward base; its base about equal to distance between exposed nostrils. Pelvics extending rearward beyond rear levels of pectorals for a distance about half as great as distance between eyes, or a little more; with abruptly rounded corners and nearly straight margins; the distal margin weakly scalloped corresponding to its supporting cartilaginous rays; anterior margin about 90 % as long as distance from pelvic origin to inner rear corner. Claspers of mature male moderately stout, cylindrical, reaching rearward as far as first dorsal, perhaps beyond it; their tips simple, without terminal spines or other rigid projections.

Color. Greyish, reddish chocolate, or dusky brown above, the edges of the disc paler; dorsal fin either of same hue as disc or pale greyish; tail either uniform brown or dusky throughout its length, or palest toward base but darkening to nearly black toward tip; tubercles above eyes of males described as either whitish or dusky. Lower surface either pure white or whitish tinged with hue of upper surface, the pectorals dusky toward their tips. Iris described as slaty brown, the pupil ringed with black. Teeth green in all specimens seen by us.

Relationship to Extralimital Species. The chief differences between *M. freminvillii* of

the western Atlantic and *M. aquila* of the eastern Atlantic are the greater size of the dorsal fin of the former[27] and its position farther forward on the tail (see Key, p. 438). A longer and more narrowly ovate subrostral lobe may also prove to be a diagnostic character for *M. freminvillii* as contrasted with *M. aquila* (Fig. 102), though accounts of the latter differ widely in this respect. Also, the single large conical tubercle that develops on the inner anterior rim of each orbit in mature males appears to be less prominent in *M. aquila* than in *M. freminvillii*, or it may even be absent.[28]

Size. The usual breadth at birth is probably about 250 mm, for embryos about 200 mm wide have been born prematurely when their mothers were captured.[29] Males may mature at a breadth no greater than about 600–700 mm.[30] The largest specimens of which we find definite record are: one 34 inches wide from Chesapeake Bay,[31] and a female of about the same size (860 mm wide) from Woods Hole, Massachusetts (see Study Material).

Developmental Stages. This is one of the Rays in which the uterus is known to be lined with villi. Gravid females, taken near Cape Lookout, North Carolina, have been reported as containing six embryos folded together in pairs, the heads and tails of each pair in reversed position.[32]

Habits. The stomachs of specimens taken near Woods Hole, Massachusetts, contained lobsters chiefly, also crabs (*Cancer*), clams (*Mya*), and large gastropods (*Lunatia*). Presumably it feeds similarly on the larger crustacea and on hard-shelled mollusks throughout its range elsewhere. Nothing else is known of its method of life beyond what applies to the genus as a whole (p. 436). In the northern part of its range it is known as a summer and early autumn visitor only. In the years when it is most plentiful it appears to arrive about as early and to linger as late near its extreme northern boundary as it does along the middle Atlantic states; the earliest and latest reports of it are for June and October both off southern Massachusetts and in Chesapeake Bay. No definite information is available as to its seasonal occurrence anywhere to the southward. But sea temperatures suggest that it may be expected off North Carolina from May through November and in Brazilian waters the year round. It is probably a year-round inhabitant also in the West Indian and Caribbean regions, if it occurs there with any regularity, which is not yet known.

Numerical Abundance. This Eagle Ray has never been reported as abundant anywhere, except by its original describer, and subsequent information makes it highly probable that his characterization of it as "very common"[33] in the small inlets on the Rhode Island Coast, where he "had an opportunity of examining many fresh specimens

27. Base of dorsal fin only about 70 % as long as distance between inner ends of exposed nostrils in *M. aquila*, but about as long as distance between nostrils in *M. freminvillii*.
28. See page 437 for comparison with eastern Pacific species.
29. Gudger (Proc. biol. Soc. Wash., *26*, 1913: 101). The two smallest specimens in our Study Material, 140 and 144 mm wide, are embryos and two others, 170 and 183 mm, seem to be also.
30. The claspers of males 603, 710 and 760 mm long, in our Study Material, appear to be fully developed.
31. Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 69.
32. Gudger, Proc. biol. Soc. Wash., *26*, 1913: 101; Coles, Proc. biol. Soc. Wash., *28*, 1915: 94.
33. Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 113.

recently rejected by the fishermen," was based on an unusual incursion. Only once, in fact, do we find it spoken of as "frequent" in recent literature.[34] Twelve were reported during the summer of 1912 near Cape Lookout; collections for five weeks in September and October 1922, partly taken with an 1800-foot commercial seine, yielded only eight in lower Chesapeake Bay; and other records for it along New Jersey, near New York, and from southern Massachusetts have been based on odd individuals only. We have heard of none at Woods Hole during the past ten years, though 20 were taken in a trap at Waquoit a few miles to the eastward during the month of June alone[35] in 1871.

Published information, plus the considerable representation of it in museum collections, suggests that it is more plentiful in Brazilian waters than anywhere to the northward. However, definite information is lacking as to its numerical abundance there.

Relation to Man. It is not plentiful enough anywhere to be of importance to fishermen, whether positively as a potential source of human food or negatively as an enemy of shellfish beds.

Range. Continental waters of the western Atlantic from middle Brazil to New York and as a stray to southern Massachusetts and Cape Cod.

Details of Occurrence. Caution is called for in outlining the range of the two species of *Myliobatis* in the western Atlantic because of the possibility that some of the nominal reports of *M. freminvillii* may have been based on *M. goodei*, so closely do the two species resemble one another in general appearance.

Descriptions or illustrations of the specimens concerned, or recent examination of them, establish the presence of *M. freminvillii*, as contrasted with *M. goodei*, at the following localities, south to north: Rio de Janeiro; vicinity of Cape Lookout, North Carolina; Chesapeake Bay; eastern shore of Virginia; Maryland; Sea Island City, New Jersey; Noank, Connecticut; Rhode Island; vicinity of Woods Hole and Provincetown at the tip of Cape Cod, Massachusetts. In view of the fact that South Carolina is the most northerly station where *M. goodei* has certainly been found (see Study Material, p. 446), it is highly probable that the considerable number of nominal reports for *M. freminvillii* by name only from North Carolina, the Atlantic Coast of Maryland, New Jersey, New York, Narragansett Bay, Buzzards Bay, and Woods Hole do actually refer to *freminvillii*.

The most interesting feature of its known range is that it seems never to have been recorded with proof of identity from the northern coast of South America; from the Caribbean; from the southern or northern Gulf of Mexico;[36] from anywhere among the West Indies; or from Florida. But we suspect that this latitudinal gap of approximately 2,400 miles in its established range indicates merely that its presence has been overlooked, for we have found nothing to separate the Brazilian specimens studied from others taken at various localities along the coasts of the United States.

34. Fowler (Proc. biol. Soc. Wash., *33*, 1920: 146), off Cape May County, New Jersey.
35. Lyman, Rep. Mass. Comm. inl. Fish., 1872: 53.
36. There are nominal reports of it for Galveston, Texas and for Mexico; see Probable References, p. 446.

Synonyms and References:[37]

Myliobatis[38] *freminvillii*[39] Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 111 (descr., cf. European *aquila*, nos., Rhode Island); DeKay, Zool. N.Y., 4, 1842: 376 (descr., size, Rhode Island by ref. to Lesueur, 1824); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed, E. Coast N. Amer.); Günther, Cat. Fish. Brit. Mus., 8, 1870: 488, footnote 2 (ref. to Lesueur, 1824); Lyman, Rep. Mass. Comm. inl. Fish., 1872: 53 (shape of snout, nos., Waquoit, Mass.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (listed, C. Cod to Florida); Verrill and Smith, Rep. U. S. Comm. Fish. (1871–1872), 1873: 521 (stom. contents, Vineyard Sound); Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 185; 2nd ed., 1876: 157 (listed, Chesapeake Bay); Jordan and Gilbert, Proc. U. S. nat. Mus., *1*, 1879: 386 (Beaufort, N. Carolina, tail only, ident. probable because of local.); Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (listed, E. Florida); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 51 (descr., color, listed, C. Cod to Brazil); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 160 (listed, S. Carolina); Garman, Proc. U. S. nat. Mus., *8*, 1885: 39 (descr., cf. *M. goodei*, Connecticut and Virginia); Jordan, Proc. U. S. nat. Mus., *9*, 1886: 26 (listed, Beaufort, N. Carolina, ident. probable because of local.); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed); Jenkins, Johns Hopkins Univ. Stud. Biol., *4*, 1887: 84 (listed, Beaufort, N. Carolina by ref. to Jordan and Gilbert, 1879); Bean, Bull. U. S. Fish Comm., *7*, 1889: 151 (listed, New Jersey, but reports of Sting Rays flapping at surface probably not this species); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 89 (descr., C. Cod to Brazil); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, C. Cod to Brazil); Linton, Proc. U. S. nat. Mus., *20*, 1897: 424, 551 (cestode parasites, Woods Hole, Mass.); Smith, Bull. U. S. Fish Comm., 17, 1898: 90 (nos., Woods Hole region); Linton, Bull. U. S. Fish Comm., *19*, 1901: 275 (stom. contents, Woods Hole), 433 (cestode and trematode parasites, Woods Hole); Bean, Bull. N.Y. St. Mus., 60, Zool. *9*, 1903: 58 (descr. by ref. to earlier authors, but schools of Sting Rays reported off Hereford Inlet, New Jersey perhaps not this species); Fowler, Rep. N. J. Mus. (1905), 1906: 79 (listed, New Jersey); Science, N. S. *24*, 1906: 596 (listed, New Jersey); Tracy, Rep. R. I. Comm. inl. Fish., 1906: 48 (listed, Narragansett Bay and other New England locals. by ref. to earlier authors); Fowler, Rep. N. J. Mus. (1906), 1907: 262, pl. 81 (descr., ill., New Jersey); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 191, 210 (diagn., refs., Rio de Janeiro); Smith, H. M., N. C. geol. econ. Surv., *2*, 1907: 46 (diagn., Beaufort, N. Carolina, ident. probable because of local.); Kendall, Occ. Pap. Boston Soc. nat. Hist., 7 (8), 1908: 15 (New England locals.); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 475 (no. of tail spines, Sea Island City, New Jersey); Tracy, Rep. R. I. Comm. inl. Fish., 1910: 63 (same as Tracy, 1906); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 432, pl. 35, pl. 39, fig. 2, pl. 54, fig. 3 (descr., ill., C. Cod, New York, Brazil); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 101 (embryos, nos., C. Lookout, N. Carolina); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739 (stom. contents, parasites, Woods Hole); Fowler, Copeia, 2, 1914: [2] (listed, Maryland); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (embryos, C. Lookout, N. Carolina); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 277, pl. 48, fig. 1 (meas., photo teeth, Beaufort, N. Carolina, ident. probable because of local.); Fowler, Proc. Acad. nat. Sci. Philad., *69*, 1917: 109 (listed, New Jersey); Proc. Boston Soc. nat. Hist., *35*, 1917: 111 (listed, Newport, Rhode Island); Occ. Pap. Mus. Zool. Univ. Mich., 56, 1918: 2 (listed, New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 146 (nos., New Jersey); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 91 (descr.); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 46 (same as Ribeiro, 1907); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 10 (cestode parasites, Woods Hole); Nichols and Breder, Zoologica N.Y., *9*, 1927: 28 (listed New York to south. New England, food); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 69 (descr., color, size, nos., Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 38 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 19 (genl.); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 32 (descr., Maryland and Chesapeake Bay); Breder and Nigrelli, Copeia, 1934: 193 (listed, New York); Fowler, Proc. Acad. nat. Sci. Philad., *89*, 1937: 304 (listed, New Jersey); Norman and

37. The following list is confined to references that seem almost certainly to apply to this species (not to *M. goodei*) because of locality, included description, or reference to earlier accounts. See p. 450 for a list of nominal references that might apply either to *M. freminvillii* or to *M. goodei*.

38. Sometimes spelled *Myliobates*.

39. Sometimes spelled *fremenvillii* or *freminvillei*.

Fraser, Giant Fishes, 1937: 77 (listed, C. Cod to Brazil); Breder, Bull. N. Y. zool. Soc., 41, 1938: 28 (listed, New York Harbor).

Myliobatis bispinosus Storer, Proc. Boston Soc. nat. Hist., *1*, 1842: 53 (Holmes Hole, Mass.); Boston J. nat. Hist., *4*, 1842: 188 (same specimen as the foregoing); Ayres, Boston J. nat. Hist., *4*, 1843: 29, pl. 13, fig. 1 (descr., ill., Long Island, New York); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed, E. Coast N. Amer.); Duméril, Hist. Nat. Poiss., *1*, 1865: 637 (descr., after Ayres 1843); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 488, footnote 1 (ref. to Storer 1842).

Myliobatis acuta Ayres, Proc. Boston Soc. nat. Hist., *1*, 1842: 65 (diagn., color, Long Island, New York); Linsley, Amer. J. Sci., *47*, 1844: 79 (listed, Long Island, New York); Storer, Mem. Amer. Acad. Arts Sci., N. S. *2*, 1846: 514 (diagn., size, Mass. and Conn. by ref. to Storer and Ayres); Mem. Amer. Acad. Arts Sci., N. S. *9*, 1867: 245, pl. 39, fig. 4; also, Fishes Mass., 1867: 269, pl. 39, fig. 4 (descr., color, ill., Holmes Hole, Mass.); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 488, footnote 1 (ref. to Storer and Ayres).

Aetobatus freminvillii Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 31 (listed, C. Cod to Brazil).

Holorhinus freminvillei Fowler, Arqu. Zool. Estad. São Paulo, *3*, 1942: 132 (listed, Rio de Janeiro).

Probable References:

Aetobatis freminvillei Evermann and Kendall, Bull. U. S. Fish Comm., *12*, 1894: 96 (listed, Galveston, Texas).

Myliobatis freminvillii Borodin, Bull. Vanderbilt Oceanogr. (Mar.) Mus., *1*, 1928: 5 (listed, W. Indies); Beltran, List. Peces Mexicanos, 1934 (listed, Mexico; not seen).

Myliobatis goodei Garman 1885

Figure 104

Study Material. Five females, 270–990 mm wide, from Uruguay and from Rio Grande do Sul and Rio de Janeiro, Brazil, and Charleston, South Carolina, in U.S. National Museum and Harvard Museum of Comparative Zoology.

Distinctive Characters. Myliobatis goodei differs from *M. freminvillii* (the only other western Atlantic Ray with which it could be confused) in the relatively broader separation between the inner ends of the more posterior pairs of gill openings,[40] in its relatively smaller dorsal fin,[41] in the position of the dorsal fin farther rearward, in the more broadly rounded outer corners of its pectorals (cf. Fig. 104 with 102) and the somewhat more obtusely blunted posterior corners. Also, the width of the trunk between the axils of the pectorals is considerably greater in medium-sized and large examples of *M. goodei* than in *M. freminvillii*,[42] though it is doubtful whether there is any significant difference in this respect between small specimens of the two species. The subrostral fin is usually somewhat shorter in *M. goodei* than in *M. freminvillii*, at least in females, but no sharp line can be drawn between the two in this respect; nor is it known whether this difference applies to the opposite sex, since males of *M. goodei* have not been seen.

Description. Proportional dimensions in per cent of extreme breadth of disc. Female,

40. Inner ends of fifth pair of gill openings separated by a distance more than 1.5 times as great as that between exposed ends of nostrils in *M. goodei*, but less than 1.25 times in *M. freminvillii*.

41. Base of dorsal fin only 0.6–0.8 as long as distance between exposed ends of nostrils in *M. goodei*, but 0.9–1.0 times in *M. freminvillii*.

42. Wider than between the inner ends of the fifth pair of gill openings in *M. goodei* but considerably narrower than that in *M. freminvillii*.

665 mm broad, from Charleston, South Carolina (U. S. Nat. Mus., No. 21343). Female, 990 mm broad, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 994).

Disc: length 59.5, 60.8.

Snout length: in front of orbits 5.1, 5.0; in front of mouth 7.2, 8.6.

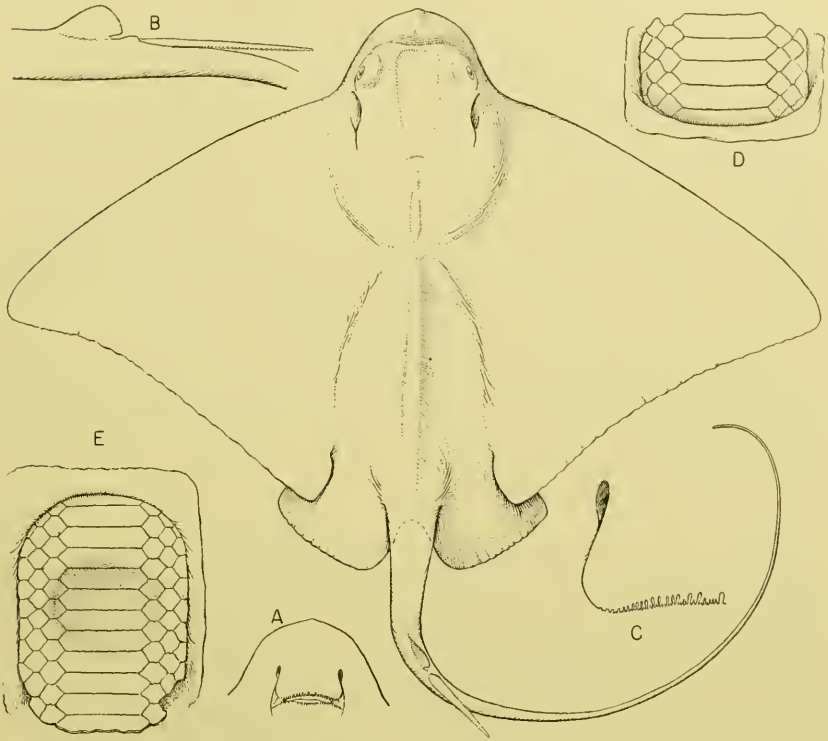

FIGURE 104. *Myliobatis goodei*, female, about 690 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 399). *A* Lower side of snout to show nostrils and mouth. *B* Side view of dorsal fin and tail spine, about 0.4×. *C* Right-hand side of nasal curtain, about 0.8×. *D* Upper teeth (anterior row uppermost), and *E* Lower teeth (anterior row lowermost), about 0.8×.

Orbits: horizontal diameter 4.8, 3.5; distance between 9.0, 9.8.

Spiracles: length 5.6, 6.9; distance between 13.6, 14.7.

Mouth: breadth 8.4, 9.6.

Exposed nostrils: distance between inner ends 5.8, 5.7.

Gill openings: lengths, 1st 2.3, 2.6; 3rd 2.4, 2.8; 5th 1.5, 1.8; distance between inner ends, 1st 16.2, 17.5; 5th 9.6, 10.8.

Dorsal fin: vertical height 2.1, 2.1; length of base 4.4, 4.3.
Pelvics: outer margin 12.8, 13.7.
Distance: from tip of snout to center of cloaca 55.2, 60.3; from center of cloaca to origin of tail spine 17.6, 22.2; to tip of tail 87.0, —.

Disc 1.5–1.7 times as wide as long from tip of subrostral fin to level of posterior corners of pectorals; anterior margins weakly convex; posterior margins moderately concave, increasingly so outward; outer corners moderately rounded (a little more broadly so than in *M. freminvillii*); posterior corners about a right angle, blunted at tip; inner margins moderately convex (Fig. 104), about as long as breadth of mouth. Axis of greatest breadth about $^2/_3$ of distance rearward from tip of subrostral fin toward axils of pectorals; breadth between axils of pectorals about as great as distance between outer ends of first pair of gill openings on large specimens and about as great as distance between inner ends of first gills on small ones; thickness of disc at pectoral girdle a little less (85–93 %) than distance between spiracles. Tail moderately stout anterior to dorsal fin and spine, tapering thence rearward to whiplash tip, its length from center of cloaca a little more than twice as great as distance from tip of snout to center of cloaca in smallest specimens, probably about as long as in *M. freminvillii* in larger ones.[43]

One tail spine on specimens seen (probably sometimes two); its origin close behind rear end of base of dorsal and posterior to axils of pelvics by a distance a little more than 1.5 times as great as distance between eyes; about as long as distance between eyes or a little longer when fully developed; about $^1/_7$ as broad as long at base where exposed; its lateral teeth much as in *M. freminvillii*.

Skin apart from tail spine perfectly smooth on females; conditions on male not known.

Upper surface of crown weakly concave longitudinally from forehead to level of spiracles, as in *M. freminvillii*. Orbits not prominent, about 40–60 % as long as distance between orbits. Spiracle much as in *M. freminvillii*, its length about 1.1–1.9 times as great as that of orbit. Gill openings sinuous, as in *M. freminvillii*, first to third about 0.5–0.8 times as long as orbit; distance between inner ends of first pair 2.8–3.1 times as great as distance between exposed nostrils; distance between inner ends of fifth gills about 56–62 % as great as that between first gills. Free margin of joint nasal curtain straight or weakly concave, irregularly fringed with short lobelets, single, bifid or trifid at tips. Mouth weakly arched, occupying about half of breadth of head. Floor of mouth posterior to dental plate with 5–6 short fleshy papillae; transverse curtain on roof of mouth with fringed edge.

Teeth similar in the two jaws; normally $\frac{7}{7}$, but occasionally $\frac{8}{7}$ from interpolation of an extra series on one side or the other;[44] those of median series about four times as broad (transversely) as long (anteroposteriorly) and about four times as broad as those of lateral series; their length (anteroposteriorly) about $^1/_6$–$^1/_4$ as great as diameter of eye;

43. Maximum length about 1.8 times as great as length of disc in larger specimens seen, but tip evidently lost.
44. Eight rows in the upper jaw, seven in the lower jaw, in one specimen in our Study Material; seven in both jaws in all others.

those of all lateral series only about as broad as long; free anterior margins of median series of teeth weakly concave in upper jaw but straight in lower; 4–5 teeth exposed (hence in function simultaneously) in upper jaw and 9–10 exposed in lower jaw on newborn specimens; about 11 rows exposed in adults.

Subrostral fin broadly rounded, its midpoint sometimes with a low protuberance, its length anteriorly from level of orbits about 0.5–0.8 as great as distance between orbits. Minimum width of lateral continuation of pectorals along sides of head about $^1/_3$–$^1/_2$ as great as length of subrostral fin. Dorsal fin about half as high as long, its base about 0.6–0.8 as long as distance between exposed nostrils, its anterior margin nearly straight, posterior margin weakly indented basally; its origin posterior to rear limits of pelvics by a distance 2–3 times as long as base of dorsal.[45] Pelvics extending rearward beyond rear limits of pectorals for a distance about $^2/_3$ as great as distance between eyes; with rounded corners and nearly straight or weakly convex margins, much as in *M. freminvillii*, but averaging a little broader relative to their lengths; the anterior margin about 60 % as long as distance from origin of pelvic to rear corner.

Color. Preserved specimens are chocolate- or greyish-brown above, brownish white below, with the tips of pectorals more or less dusky.[46]

Relationship to Extralimital Species. M. goodei resembles small specimens of *M. aquila* of the eastern Atlantic[47] in the shortness and obtuseness of its subrostral fin, in the relatively small size of its dorsal fin, and in the position of the latter. But it differs from *M. aquila* in the considerably greater distances between the inner ends of the more posterior pairs of gill openings relative to other proportionate dimensions,[48] perhaps in blunter posterior pectoral corners, and seemingly in a relatively smaller eye as well.[49]

The color of the teeth may also prove diagnostic, these being green in all specimens of *M. goodei* that we have examined, as in *M. freminvillii* (p. 442), also, but they are amber yellow in the only two *M. aquila* that we have seen.[50] See p. 437 for comparison with eastern Pacific species.

Size. Neither the size at which males become sexually mature nor the maximum size is known. A female, 990 mm wide, is the largest recorded so far.

Developmental Stages. Embryos of this Ray have not been seen.

Habits. Nothing is known of the habits of *M. goodei* as distinguished from those of its close relative *M. freminvillii.* Presumably its diet is the same as that of the latter; i. e., whatever large crustacea and hard-shelled mollusks may be locally available.[51] All

45. About three times as long as base of dorsal in two smaller specimens seen, twice as long in largest seen.
46. No information is available as to the color in life.
47. See p. 443 for further discussion of this character in *M. aquila.*
48. Distance between inner ends of fifth pair of gill openings only about 1.2 times as long as distance between exposed nostrils in two small specimens of *M. aquila* from the Mediterranean.
49. Horizontal diameter of eye only about $^1/_3$ (30–37 %) as great as distance between inner ends of nostrils in *M. goodei*; about $^1/_2$ (50 %) in *M. aquila.*
50. We have found no published statement as to the color of the teeth in any of the numerous accounts of *M. aquila.*
51. A *Myliobatis* recorded as *M. aquila* from Rio Grande do Sul in southern Brazil (von Ihering, Rev. Mus. paul., 2, 1897: 35), but without further clue as to its specific identity, contained bivalve mollusks (*Solecurtus*) in its stomach.

records for it up to date have been from close to the shore, but there is no report of its presence in fresh water (see also *Habits* of the genus, p. 436).

Range. Localities where the presence of *M. goodei* (as contrasted with *M. freminvillii*) has been positively established by published descriptions or illustrations, or by our Study Material, include South Carolina; "Central America";[52] Rio de Janeiro and Rio Grande do Sul, Brazil; and Uruguay.[53] It seems probable also that some, perhaps all, of the published reports of *M. aquila* from the lower Parana River, from the estuary of the Rio de la Plata, and from northern Argentina (see References, p. 450) were based on *M. goodei.* The fact that its known range extends farther poleward in the southern hemisphere than that of *M. freminvillii* lends special interest to its scarcity off the South Atlantic seaboard of the United States, where *M. freminvillii* is well known as a summer visitor (p. 444).

Synonyms and References:

Myliobatis goodei Garman, Proc. U. S. nat. Mus., *8*, 1885: 39 (descr., cf. *M. freminvillii*, Cent. Amer.); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (3), 1898: 2755 (descr., after Garman 1885, Cent. Amer.); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 430 (descr., Cent. Amer. and Rio Grande do Sul, Brazil); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 90 (descr.); Smith, Biol. Rev. [Cambridge], *11*, 1936: 65 (listed, Rio Grande do Sul, Brazil, by ref. to Garman, 1913).

Aetobatus goodei Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 31 (listed, Cent. Amer. to Brazil).

Holorhinus goodei Fowler, Arqu. Zool. Estad. São Paulo, *3*, 1942: 132 (listed, Rio Grande do Sul, Brazil).

Probable Synonyms and References:

Myliobatis aquila von Ihering, Rev. Mus. paul., *2*, 1897: 35 (stom. contents, Rio Grande do Sul, Brazil; probably *M. goodei* because later considered by Ribeiro 1907 as distinct from *M. freminvillii*); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 82, in part (rep. for Rio Grande do Sul by ref. to von Ihering, 1897; but rep. for Rio de la Plata by ref. to Berg 1895 not identifiable as to species); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 191 (cf. *M. freminvillii*, coasts of south. Brazil); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 46 (same as Ribeiro 1907).

Holorhinus aquila Fowler, Arqu. Zool. Estad. São Paulo, *3*, 1942: 132 (listed, Rio Grande do Sul, Brazil, by ref. to Schreiner and Ribeiro 1903).

Not *Raja aquila* Linnaeus, Syst. Nat., *1*, 1758: 232.

References either to *M. freminvillii* or to *M. goodei*, but not further identifiable:

Myliobatis aquila Berg, An. Mus. nac. B. Aires, (2) *1*, 1895: 17 (listed, Montevideo, Rio de la Plata); Lahille, Rev. Mus. La Plata, *6*, 1895: 276 (listed, Rio de la Plata by ref. to Berg, 1895); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 82 (rep. for Montevideo, Rio de la Plata, by ref. to Berg, 1895, but rep. for Rio Grande do Sul, Brazil, by ref. to von Ihering 1897 probably *M. goodei*; see above); Eigenmann, Rep. Princeton Exped. Patagonia, *3* (1), 1909: 348 (listed, La Plata R., by ref. to Berg 1895); Rep. Princeton Exped. Patagonia, *3* (2), 1910: 378 (listed, Rio de la Plata); Devincenzi, An. Mus. nac. Montevideo, (2) *1*, 1920: 130 (listed, Uruguay); Marelli, Elenc. Sist Fauna B. Aires, Mem. Ministr. Obras Publ. B. Aires (1922–1923), Fishes, 1924: 549 (listed, Mar del Plata, Argentina, and Rio de la Plata); Devincenzi and Barattini, An. Mus. nac. Montevideo, (2) *2*, 1926: Suppl. Album Ictiol., pl. 5, fig. 3 (ill. not ident. as to species); McDonagh, Rev. Mus. La Plata, *34*, 1934: 95, footnote 1 (listed, Mar Chiquita, a salt lagoon, north. Argentina); Pozzi and Bordale, An. Soc. cient. argent., 120, 1935: 154 (listed, Lat. 35–40° S., Argentina); Smith, Biol. Rev. [Cambridge], *11*, 1936: 65 (listed,

52. Garman, Proc. U. S. nat. Mus., *8*, 1885: 39.

53. A specimen in the collection of the U. S. National Museum (No. 87685) is so labelled.

Rio de la Plata by ref. to Eigenmann, 1909); Lopez, An. Mus. Argent. Cient. Nat., *42*, 1947: 102, pl. 8 (kidney, Argentina).

Leiobatus aquila Lahille, Physis B. Aires, *5*, 1921: 63 (listed, Argentina); Marini, Physis B. Aires, *9*, 1929: 452 (listed, Puerto Quequen, Argentina).

Genus *Aetobatus* Blainville 1816

Duck-billed Rays

Aetobatus Blainville, Bull. Soc. philom. Paris, 1816: 112; also J. Physique, *83*, 1816: 262; type species, *Raja narinari* Euphrasen (Handl. K. Vetensk. Akad., *11*, 1790: 217, pl. 10), St. Bartholomew I., West Indies, designated by Gill (Proc. U. S. nat. Mus., *17*, 1894: 112).[54]

Generic Synonyms:

Raja (in part) Euphrasen, Handl. K. Vetensk. Akad., *11*, 1790: 217; Bloch and Schneider, Syst. Ichthyol., 1801: 361, and subsequent authors; for *R. narinari* Euphrasen and synonyms of it, and for *R. flagellum* Bloch and Schneider.

Myliobatis (in part) Cuvier, Règne Anim., *2*, 1817: 138, footnote 1, and subsequent authors; for *Raja narinari* Euphrasen 1790 and its synonyms; not *Myliobatis* G. St.-Hilaire 1817, 1827; see discussion, p. 434, footnote 4.

Aetobatis Müller and Henle, Arch. Naturg., (Jahrg. 3) *1*, 1837: 401; also, Charlesworth Mag. nat. Hist., 2, 1837: 91 (descr., but no species named); Plagiost., 1841: 179; type species, *Raja narinari* Euphrasen 1790.

Aetobates Richardson, Rep. Ichthyol. China, Japan, 1846: 198; for *Raja flagellum* Bloch and Schneider (Syst. Ichthyol., 1801: 361, pl. 73); ? emended spelling for *Aetobatis* Müller and Henle 1837, 1841.

Stoasodon Cantor, J. Asiat. Soc. Beng., 1849: 1416; type and only included species, *Raja narinari* Euphrasen 1790.

Aetobatus Duméril, Mém. Acad. Sci. France, *27* (1), 1856: 145; ? emended spelling for *Aetobatis* Müller and Henle 1837, 1841.

Goniobatis Agassiz, L., Proc. Boston Soc. nat. Hist., *6*, 1859: 385; type species, *Raja flagellum* Bloch and Schneider 1801, designated by Jordan (Genera Fish., 2, 1919: 277); *G. meleagris* L. Agassiz, Sandwich [Hawaiian]) Is. also included.

Pteromylaeus Walford, Mar. Game Fish. Pacif. Coast, 1937: pl. 26, fig. C, for "Mexican Eagle, *Pteromylaeus* sp.," equals *Aetobatus narinari* (Euphrasen) 1790.

Not *Raja* Linnaeus, Syst. Nat., *1*, 1758: 231.

Not *Aetobatis* Blainville, in Vieillot, Faune Franç., 1825: 38; type and only included species, *Raja aquila* Linnaeus 1758, equals *Myliobatis* Cuvier 1817; see discussion, p. 434, footnote 4.

Not *Pteromylaeus* Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 437; type species, *Myliobatis asperrimus* Jordan and Evermann (Bull. U. S. nat. Mus., 47 [3], 1898: 2754), designated by Jordan (Genera Fish., 4, 1920: 548).

Generic Characters. Disc lozenge-shaped, much broader than long. Tail much longer than disc, either with or without a serrate-edged spear-pointed spine (or spines) with forked root. Pectorals entirely interrupted along sides of head, their subrostral portion forming a separate lobe or fin projecting prominently forward from below anterior part of head at a considerably lower level than pectorals proper (p. 466); rays supporting main portions of pectorals much stouter than those of subrostral fin. Dorsal fin above posterior parts of pelvics. Free posterior margin of transverse curtain on roof of mouth nearly straight, coarsely fringed; free anterior margin of fold overlapping youngest rows of upper teeth smooth, but rearward there are two irregular transverse

54. See discussion, p. 434, footnote 4.

rows of short blunt papillae, 7–8 in the anterior row, 3–6 in the posterior row; floor of mouth with a transverse row of 2–4 slender papillae, continued on either side as a thin fold with irregular margin. Teeth broad transversely; in a single series in each jaw; embryos with one or two of anterior rows in two series (p. 457); teeth of each jaw in close contact with each other from front to rear, thus forming a compact dental plate; the lower plate grinding against the upper by forward-rearward movements of the lower jaw. Anterior and posterior surfaces of gill arches, inward from gill filaments, each with a longitudinal row of tapering papillae, widely spaced.

Characters otherwise those of the family (p. 433).

Range. Tropical to warm temperate belts of all oceans in coastwise waters. Red Sea; Indian Ocean in general, southward in its western side to Natal and Madagascar; Malayan-East Indian region; Philippines; Queensland and New South Wales; Cochin-China and southern Chinese Coast; Melanesian, Micronesian, and Polynesian groups, including Hawaiian Islands; west coast of America from Panama and the Galapagos Islands to Gulf of California, and to Oregon as a stray;[55] Atlantic from Brazil northward to North Carolina, occasionally to Chesapeake Bay (p. 462) in the western side; Angola (about Lat. 11° S) to the vicinity of Cape Verde in the eastern Atlantic.

Species. The only species of the genus known in the western Atlantic, *Aetobatus narinari* (Euphrasen) 1790, appears to be cosmopolitan in suitable situations in tropical-subtropical latitudes, not only in both sides of the Atlantic but across the whole breadth of the Indo-Pacific as well, from East Africa and the Red Sea to the west coast of Central America. A second species, *Aetobatus flagellum* (Bloch and Schneider) 1801, seemingly distinguishable from *A. narinari* by its plain coloration and by its more or less prickly disc and tail, which was originally described from the Coromandel Coast, has been reported from the eastern tropical Atlantic[56] (apparently with justice) as well as from the Bay of Bengal, Red Sea, Indian Ocean, China, East Indies, and Hawaii.[57]

It is certain that most of the reports of *Aetobatus* (as here understood), regardless of the part of the world in which they were taken, refer to one or the other of these two species. However, it is possible that some from the Indo-Pacific may have been based on a third species which has masqueraded as *A. narinari* (or as one of the synonyms of the latter) because of its spotted coloration but which is separable from *A. narinari* and from *A. flagellum* by the lack of a tail spine; a South Seas specimen thus characterized has been reported recently as *A. ocellatus* (Kuhl) 1823.[58] But the specimen may have been one in which the scar caused by the loss of the tail spine had healed over entirely, or it may have been an abnormal individual. Also, the specific name *guttata* (Shaw) 1804 as distinct from *narinari* has been applied[59] to an Indian *Aetobatus* with the spots confined to the posterior part of the disc and with conical subrostral fin, but this seems to us likely to fall within the limits of variation of *A. narinari*.[60]

55. Dimick, Copeia, 1944: 185.
56. Rochebrune, Act. Soc. linn. Bordeaux, (4) 6, 1882: 56.
57. For list of Indo-Pacific localities for *A. flagellum*, see Fowler (Bull. U. S. nat. Mus., 100 [13], 1941: 473).
58. Fowler, Bull. U. S. nat. Mus., 100 (13), 1941: 475.
59. By Annandale, Mem. Indian Mus., 2, 1909: 55, fig. 10B, 56.
60. The form described by Garman (Mem. Harv. Mus. comp. Zool., 36, 1913: 442) as *Aetobatus ocellatus*, new species,

Key to Atlantic Species

1 a. Upper surface of disc and pelvics conspicuously pale-spotted on a dark ground; disc and tail entirely smooth except for tail spines.

narinari (Euphrasen) 1790, p. 453.

1 b. Upper surface of disc and pelvics plain-colored; upper surface of head, midzone of disc, and tail more or less prickly on large specimens.

flagellum (Bloch and Schneider) 1801.
Indian Ocean, China, Red Sea, tropical West Africa.

Aetobatus narinari (Euphrasen) 1790

Spotted Duck-billed Ray, Spotted Eagle Ray

Figures 105, 106

Study Material. Eighteen specimens, 350–1,220 mm wide (14–48 in.), from: Bermuda; Beaufort, North Carolina; Gulf of Mexico at Tampa, Florida, Main Pass, Louisiana, and Gulf of Campeche; Bahamas, Culebra, Puerto Rico, and vicinity of Havana, Cuba in the West Indies; Pernambuco and Rio de Janeiro, Brazil; dental plates of Rio de Janeiro specimen about 560 mm wide; a head of one from Anway Bay, Gulf of Venezuela; an immature male, 110 mm wide, of unknown origin, labelled "Europe"; also four specimens, 515–748 mm wide, and five embryos, 170–250 mm wide, from Pacific Panama, and one, 500 mm wide, from the Hawaiian Islands; in Harvard Museum of Comparative Zoology and the U. S. National Museum.

Distinctive Characters. The color pattern of *Aetobatus narinari* is sufficiently spectacular to place it at a glance among Rays of the western Atlantic. And recognition of old faded specimens or of those that have been so dried that the spots have disappeared is made easy by the fact that Rays of its genus stand alone in having only one series of broad flat teeth in each jaw, combined into a single dental plate.

Description. Proportional dimensions in per cent of extreme breadth of disc. Male, 530 mm broad, from Bermuda, and female, 595 mm broad, from Florida (Harv. Mus. Comp. Zool., Nos. 1400 and 36327 respectively).

Disc: vertical length 57.9, 58.7.
Snout length: in front of orbits 6.6, 7.0; in front of mouth 11.1, 11.1.
Orbits: horizontal diameter 4.3, 4.4; distance between 9.6, 10.4.
Spiracles: length 5.1, 4.9; distance between 10.4, 9.9.
Mouth: breadth 6.0, 5.9.
Exposed nostrils: distance between inner ends 4.1, 4.5.
Gill openings: lengths, 1st 1.9, 1.7; 3rd 2.3, 1.9; 5th 1.3, 1.3; distance between inner ends, 1st 13.7, 14.5; 5th 9.4, 9.4.

and which was identified by him with the "Eel Tenkee," or "Raja ocellata; capite magno, exerto; . ." of Russell (Fish. Coromandel, *1*, 1803: 5, pl. 8), appears to fall within the limits of variation of *A. narinari* in both of the characters that Garman thought distinctive for it, namely shape of subrostral fin and color pattern. Unfortunately the specimen on which he based his account appears to be in existence no longer.

Dorsal fin: vertical height 3.2, 3.0; length of base 4.5, 4.0.
Pelvics: outer margin 13.4, 14.1.
Distance: from tip of snout to center of cloaca 52.8, 53.0; from tip of snout to dorsal 57.7, 58.2.

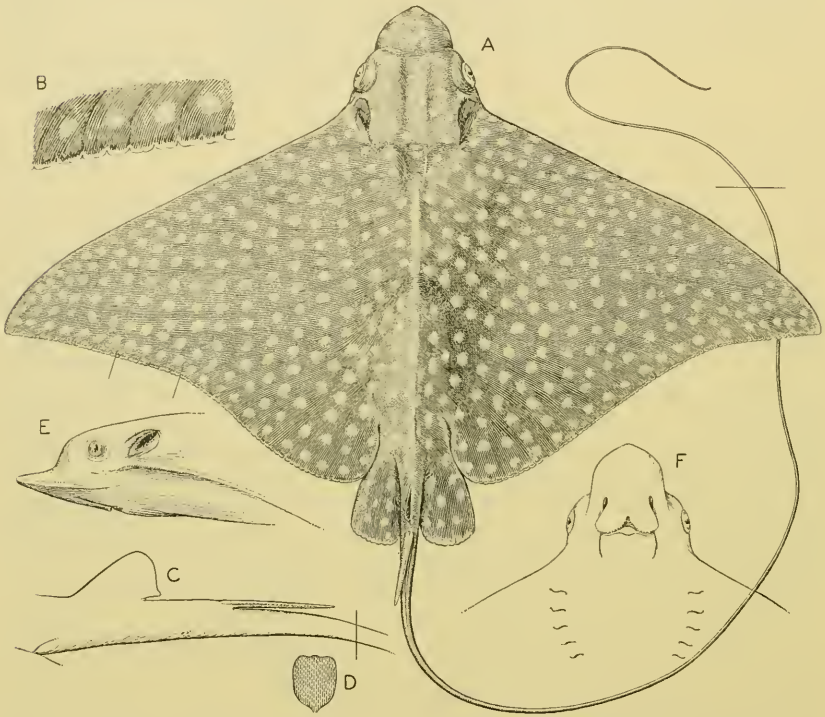

FIGURE 105. *Aetobatus narinari*. *A* Juvenile male, 530 mm wide, from Bermuda (Harv. Mus. Comp. Zool., No. 1400). *B* Part of outer posterior margin of disc of same to show color pattern, about 0.8×. *C* Side view of base of tail of same to show dorsal fin and tail spine, about 0.5×. *D* Cross section of tail of same, at point marked on *C* by a crossline, about 1.7×. *E* Side view of head of another specimen of about the same size, from Main Pass, Louisiana (U. S. Nat. Mus., No. 127296), about 0.3×. *F* Lower surface of head of same to show nasal curtain, mouth, and gill region.

Disc from level of front of spiracles to rear limits of pectorals about 2.1 times as broad as long, lozenge-shaped, with main portion of pectorals originating from sides of head about opposite anterior ends of spiracles; anterior margins at first nearly straight, then increasingly convex outwardly; outer corners narrow with blunted tips; posterior margins concave along outer $^2/_3$ but moderately convex toward broadly rounded poste-

rior corners, merging insensibly into moderately convex inner margins. Trunk opposite spiracles about 1.0–1.2 times as deep as distance between spiracles and at level of pectoral girdle about 1.1–1.4 times as deep (thus much deeper than in the dasyatids or Butterfly Rays); progressively thinner posteriorly and outwardly. Tail, from center of cloaca, up to a little more than 3.5 times as long as body from cloaca to tip of snout when intact in small specimens;[61] perhaps somewhat shorter relatively in larger individuals; more or less of its terminal part often lost; ovoid in cross section as far rearward as tail spines, rounded and extremely slender thence rearward to tip; upper and lower surfaces of tail each with a low longitudinal ridge originating close behind point of emergence of free portion of tail spine (or most posterior member of the group of spines if there are two or more) and distinguishable rearward for a distance somewhat more than twice as long as distance from axils of pelvics to spine.

Tail spines 1–3 in specimens seen, 4–5 reported, perhaps most commonly two,[62] similar in cross section to those of the dasyatid Sting Rays, with spear-like tip, recurved lateral teeth, and forked root; origin of spine (or of first spine if there be two or more) close behind rear tip of dorsal fin; free portion of the longest spine seen about half as long as distance between spiracles or nearly as long as distance from its origin to root of tail at axils of pectorals.

Skin apart from tail spines perfectly smooth.

Head anterior to spiracles projecting conspicuously from general outline, high-arched, its dorsal surface sloping abruptly downward in rounded contour a little anterior to eyes; its upper surface with a broad shallow median furrow from level of front of eyes to level of posterior ends of spiracles; sides of head anterior to spiracles nearly flat or weakly convex, somewhat converging downward; lower surface of head weakly convex transversely. Orbits only moderately prominent; eyes circular, their upper margins about at point of transition between sides and dorsal surface of head; their diameter about 40–45 % as long as distance between eyes and 80 % as long as greatest length of spiracles. Spiracles close behind eyes but at a higher level, encroaching on upper surface of head, wide open in all specimens examined, their length a little less than half as great as shortest distance between them; their margin smooth, without trace of any spiracular appendage. Anterior outlines of gill openings weakly sinuous, the second and third (longest) about as long as diameter of eye or about half the diameter of orbit; fifth only about $^2/_3$ that long; distance between inner ends of first pair about 3.5 times as great as distance between exposed nostrils; distance between inner ends of fifth gills about 65–68 % as great as distance between first gills. Nostrils extending forward about to level of front of cranium, connected posteriorly with mouth by a broad shallow groove; floor of nasal groove and posterior margin of internarial septum set with low rounded knobs; nasal curtain indented in midline by a deep notch, its outer corners widely ex-

61. Relatively longer in embryos; see Developmental Stages, p. 459.

62. Among 24 specimens from Beaufort, North Carolina, and Key West, Florida, four had one spine, nine had two spines, four had three, five had four, and two had five spines (Gudger, Bull. Hist. Med., *14*, 1943: 481). One with five spines was pictured by Quoy and Gaimard (Voy. 'Uranie,' Zool., 1824: 200, pl. 43, fig. 3), and another has been reported to us from Key West, Florida, by Lt. Comm. C. Saunders, U. S. N. R.

panded rearward as rounded lobes with finely but irregularly fringed edges, roofing the nasal groves, concealing the upper jaw, and partially covering the lower lip when mouth is closed; each lobe also with a secondary flap on inner side, similarly fringed but

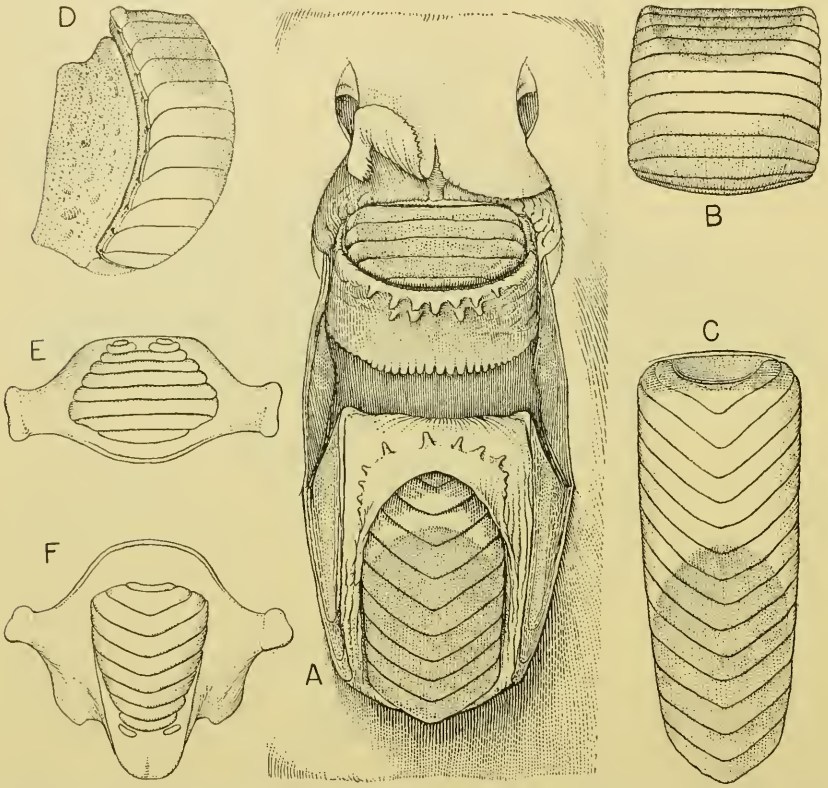

FIGURE 106. *Aetobatus narinari*. *A* Opened mouth (cut at corners) of male, 535 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 389), with right-hand nasal curtain rolled forward to show nostril, tooth bands, and floor and roof of mouth, about 1.2×. *B* Upper dental plate of female (front tooth uppermost), 565 mm wide, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 865), about 1.2×. *C* Lower tooth band of same (front tooth lowermost), about 1.2×. *D* Oblique side view of upper tooth band of same (front tooth uppermost), about 1.8×. *E* Upper teeth of embryo (front row uppermost), from Panama Bay (Harv. Mus. Comp. Zool., No. 1070), about 1.8×. *F* Lower teeth of same (front row lowermost), about 1.8×.

directed inward into nostril. Lower surface of subrostral fin and of anterior part of head set with numerous conspicuous pores and with a complex reticular series of deep narrow furrows along the midzone near the mouth, thus permitting the two lateral lobes of the

nasal curtain to be spread wide apart. Mouth occupying about $^3/_8$ of breadth of head; lower jaw bowed forward centrally. Roof of mouth with a transverse row of six or seven short blunt papillae close behind line of emergence of upper dental plate; margin of transverse curtain fringed; floor of mouth with about six papillae (Fig. 106 A).

Teeth in form of flat, narrow transverse bands in single series in each jaw after birth; one or two of anterior rows in two series in embryos.[63] Upper dental plate occupying about 80 % of breadth of mouth; strongly convex anteroposteriorly and slightly transversely; the teeth nearly straight along midsector but somewhat bowed rearward toward outer ends, the posterior teeth more strongly so than the anteriors; anterior 4–6 teeth so worn down by friction with lower teeth that their median $^2/_3$–$^4/_5$ is flat transversely, the front three or four teeth usually ground down into the shape of a shallow gutter with a flat floor (Fig. 106); most anterior upper tooth with sharp or only slightly blunted cutting edge, concealed by nasal curtain when mouth is closed; most posterior upper teeth more or less covered over by a forward-projecting flap from roof of mouth. Lower dental plate occupying about 60 % of breadth of mouth, flat, with 3–6 or more anterior teeth projecting beyond upper dental plate when mouth is closed (after death); either one or two lower teeth emerging beyond margin of lower lip at any given time depending on the stage of replacement; the free lower surfaces of those that project beyond lower lip sculptured with close-set longitudinal furrows; free edges of lower teeth strongly bowed forward transversely in obtuse subangular outline, each somewhat overlapping the one next in front of it.[64] Six to ten rows of fully calcified teeth above and 7–12 below in late embryos, increasing to about 10 above and 12 or 13 below in specimens about 600 mm wide and up to 23 above and 29 below[65] in very large individuals; these succeeded posteriorly by one or two above and by one to four below with soft outer ends, and these by one or two that are entirely soft.

Subrostral fin parallel-sided basally but bluntly wedge-shaped or ovoid toward tip, noticeably thick and fleshy, situated at a level hardly above that of mouth and projecting forward from anterior contour of head; its length anterior to anterior margins of eyes between $^1/_2$ and $^2/_3$ (60 %) as great as distance between spiracles. Dorsal fin with short free lower rear margin and subangular tip; its anterior margin weakly convex, apex moderately rounded, posterior margin weakly sinuous; its base about 1.3–1.4 times as long as its vertical height; its rear tip anterior to tips of pelvics by a distance 35–45 % as great as distance between spiracles; its origin posterior to axils of pelvics by a distance about as long as diameter of eye or half as long as its own base. Pelvics extending rearward beyond rear limits of pectorals by a distance about $^2/_3$ as great as distance between spiracles; anterior margins weakly convex, posterior margins more strongly so and slightly wavy; length of outer margin about equal to distance between first pair of gill openings.

63. There are two teeth in two of the anterior upper rows in each of four embryos from Panama (one 250 mm wide), but one tooth only in a fifth embryo.
64. For a more detailed account of the teeth of individuals of various sizes, see Gudger (Pap. Tortugas Lab., *6* (12), Publ. Carneg. Instn., 183, 1914: 291).
65. Gudger, Pap. Tortugas Lab., *6* (12), Publ. Carneg. Instn., 183, 1914: 292; Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 278.

Color. Upper surface of disc and subrostral fin olivaceous or chestnut brown; the pectorals more or less dark-rimmed, sometimes so dark as to appear almost black throughout; conspicuously marked with small white, bluish white, greenish, pearly, or yellow spots, rings (complete or broken), rings connected in pairs, rarely dumbbell-shaped figures or short streaks, these markings usually more numerous and more closely spaced posterior to spiracles than anterior to them; a rather definite row, about as large as eye, skirting posterior margin of each pectoral, sometimes so close together as to give the fin a pale-edged appearance; upper surface of pelvics of same ground tint as disc, dark-edged posteriorly, each with 6–10 larger or smaller pale spots or blotches, occasionally more or less confluent; dorsal fin uniformly dark on some specimens, but others with a pale blotch on its anterior margin; upper surface of tail dark brown or black posteriorly, sometimes with one or two pale blotches anterior to dorsal fin. Lower surfaces of disc and pelvics plain white, except tip of subrostral fin and posterior margins and tips of pelvics dusky in some cases; lower surface of tail white anterior to level of tail spine, dark thence rearward to tip in preserved specimens, but described as having pale crossbars when fresh.

The distribution, sizes, and shapes of the pale markings on the upper surface vary widely, apparently irrespective of geographic locality or age. In many individuals the spots are all about equal in size, no larger than the eye, and are comparatively evenly and closely distributed over the disc, including the head; in others the spots are much less numerous and considerably largest along the midzone of the disc. The head may have a larger or smaller number of spots or there may be none at all anterior to the spiracles; the subrostral fin is about as closely spotted as the head in some examples, but it is either plain or marked with only one or two spots in most of those that we have examined [66] Also, specimens have been described as having pale crossbars,[67] but it seems that these appear only after death, if at all.[68] The spots are described as blue if the epidermis is rubbed off, as often happens in the process of capture, and the mucous pores may be marked by black dots on specimens where the ground tint of the back of the disc is not too dark for them to show. An albino has been reported also.

Size. The smallest recorded free-living specimens were 185, 190, and 286 mm wide, but we have three specimens, 350–360 mm wide, taken at Bimini, Bahamas from a mother that was seven feet across; we have also examined an embryo of 250 mm; these data suggest that the breadth at birth may be anywhere between 170 and about 360 mm. It appears that some specimens mature at a much smaller size than others or that local populations of different sizes exist in different regions, for the claspers reach only about halfway along the pelvics on a male 1,120 mm wide[69] but reach to the tips

66. See especially Gudger (Pap. Tortugas Lab., *6* (12), Publ. Carneg. Instn., 183, 1914: 265, pls. 5–7) for an extended account, with excellent photographs, of the color patterns of Florida and North Carolina specimens, including an albino.

67. Represented as having narrow dark cross stripes in Jordan and Evermann (Bull. U. S. nat. Mus., 47 [4], 1900: pl. 16, fig. 37) and in various subsequent illustrations based on theirs.

68. None of the preserved specimens that we have examined show them. For discussion of their incidence and significance, see Gudger (Pap. Tortugas Lab., *6* [12], Publ. Carneg. Instn., 183, 1914: 272).

69. Examined by us and catalogued simply "Europe."

of the pelvics and appear to be fully formed on another only 748 mm wide, from Pacific Panama.

When it reaches full growth, this is one of the larger Rays. The few adults measured have included five that were more than six feet[70] wide and two or three others that were more than seven feet wide, the largest being a female 7 feet 7 inches wide.

Their thick bodies make Spotted Duck-billed Rays heavier than either the dasyatids or the Butterfly Rays at corresponding sizes. Recorded weights are 11 1/2 pounds at a breadth of 28 1/2 inches, 58 pounds at a breadth of about three feet,[71] 90 pounds at five feet, 120 pounds at 5 feet 2 inches, and 132 pounds at a breadth of 5 feet 9 inches, with estimated weights of 400–500 pounds for specimens 6 feet 11 inches, 7 feet 2 inches, and 7 feet 7 inches wide and about 20 inches thick.[72]

Developmental Stages. The unborn young of this Ray seem to have been reported first in 1871.[73] Presumably they are nourished (after absorption of the yolk sac) by the secretions of the villi with which the uterine wall is clothed,[74] as in the case of the young of various other Rays (pp. 337, 397, 433).

Embryos that have attained a width of 160–170 mm resemble their parents closely in general appearance, except that their tails, already armed with spines, are about 4.5 times as long as the body from cloaca to front of subrostral fin and are threadlike toward the tip, their subrostral fins are relatively somewhat shorter, and their eyes and spiracles are somewhat larger. Embryos of this size do not show any indication of the future color pattern, although the outer parts of the disc are already white-spotted on one 250 mm wide which was apparently nearly ready for birth. For an account of the embryonic teeth, see p. 457.

The unborn embryos lie rolled up lengthwise in the uterus much as in the Butterfly Rays (p. 398). Four to a litter appears to be about the usual number. It is reported by an eye witness that "in giving birth to its young, the female ray leaps high in the air."[75] But it is not known whether leaping is either necessary or usual in successful parturition.

Habits. Spotted Duck-billed Rays are said[76] to occur singly, in pairs, or in schools of several hundred individuals. They are such powerful swimmers that one 5 feet 2 inches wide, taken at Key West, Florida, dragged a 22-foot launch with engine, propeller, and three men "wherever it wished."[77]

They have often been seen leaping clear of the water and, like some other Rays,

70. One 5 feet 8 inches across and another 5 feet 9 inches, measuring respectively about 9 feet 10 inches and 10 feet from snout to tip of tail, are reported to us from Key West, Florida, by Lt. Comm. C. Saunders, U. S. N. R.
71. The weight of another of 37 inches is recorded merely as "over 25 pounds, the limit" of the balance used (Gudger, Proc. biol. Soc. Wash., *25*, 1912: 151).
72. Gudger, Pap. Tortugas Lab., *6* (12), Publ. Carneg. Instn., 183, 1914: 255.
73. By Klunzinger, Verh. zool.-bot. Ges. Wien, *21*, 1871: 686; Red Sea.
74. These were first described in 1846 by Cuvier and Duvernay (Leçons d'Anat. Comp., 1846: 92) and more recently by Coles (Bull. Amer. Mus. nat. Hist., *32*, 1913: 32).
75. Coles, Bull. Amer. Mus. nat. Hist., *32* (2), 1913: 30.
76. We have no firsthand information to contribute on their habits.
77. Gudger, Aust. Mus. Mag., *6*, 1937: 208.

they have been heard to emit a loud harsh sound while struggling in a net.[78] But it is not known whether they produce sounds of any sort under normal conditions.

They feed chiefly on bivalve mollusks, such as clams and oysters, which they crack with their dental plates. And they separate out the shells so expertly, probably by means of their buccal papillae (p. 457), that the stomach contents of many specimens from the North Carolina Coast and from the Tortugas consisted solely of the bodies of clams, often practically intact, without any fragments of shell.

So severe are their depredations, that an eyewitness writes of clam beds on the coast of North Carolina entirely destroyed by them in less than a week;[79] and they are said to be even more destructive to the pearl oyster beds of Ceylon.[80]

Around Ceylon, however, fragments of fish, of gephyrean worms, of prawns, and of octopus have been found in their stomachs,[81] evidence that their diet is not as exclusively molluscan everywhere as it is off the United States Coast. It is recorded also that the stomach of one five feet wide, taken in Ceylon waters, contained seaweed.[82]

The suggestion[83] that they use the projecting lower dental plate like a spade to dig out shellfish, etc. from sandy bottoms appears to be correct; the subrostral fin perhaps serves as an aid, and the water is kept cloudy with the sand that is disturbed as they feed along the shallows at high tide.

Spotted Duck-billed Rays are seldom encountered more than a mile or two from land, if that far, though their presence around Bermuda and among the various island groups of the tropical-subtropical Pacific proves that they are capable of extensive journeys across the open sea; there are many published records of their being taken in seines along the beach[84] and of their occurrence in more or less enclosed situations. But they appear to enter estuarine situations much less freely than do the Butterfly Rays (pp. 396, 413) or some of the more plentiful dasyatids (pp. 337, 375), for recent reports of their presence in the partially enclosed waters near Beaufort, North Carolina, have been based mainly on odd individuals, although they occur in large numbers in some years along the open coast in the vicinity of Cape Lookout nearby.[85] There is nothing in the published records of their occurrences along tropical West Africa to suggest that they enter the multiple mouths of the Senegal River,[86] though various other Rays do so, commonly.

It is probable that the Spotted Duck-billed Ray is a year-round resident through-

78. Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 30. 79. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 338.
80. Norman and Fraser, Giant Fishes, 1937: 78.
81. Pearson, Ceylon Adm. Rep. Mar. Biol., 1912–1913: E. 5.
82. Thurston, Bull. Madras Govt. Mus., *1*, 1894: 45. 83. Owen, Odontogr., 1840–1845: 47.
84. Its close relative, *Aetobatus flagellum*, has been described as frequenting the surf along the Senegal Coast (Rochebrune, Act. Soc. linn. Bordeaux, [4] *6*, 1882: 56).
85. Characterized many years ago as "very common" (Yarrow, Proc. Acad. nat. Sci. Philad., 29, 1877: 216) near Beaufort, North Carolina, but without information as to whether the reference was to the enclosed waters inside the barrier beaches or to the open coast outside.
86. *A. narinari* has been listed as occurring in fresh water (Smith, Biol. Rev. [Cambridge], *11*, 1937: 65; Gunter, Amer. Midl. Nat., 26, 1941: 196). However, the record on which this statement was based was of one from a Siamese lagoon connected with the open sea where the salinity was extremely variable, hence there is no proof that the specimen actually was taken from fresh water (Hora, Mem. Asiat. Soc. Beng., *6*, 1924: 465).

out the tropical belt of its range, and this may be true also for some distance northward along both coasts of Florida. But it reaches North Carolina only as a summer visitor, recorded in July and September, perhaps coming northward via the Gulf Stream.

Numerical Abundance. No definite information is available as to the numerical abundance of this species anywhere along the South American Coast, in the West Indian region, or around Florida. But it must be tolerably plentiful in Brazilian waters, to judge from the considerable number of specimens from the vicinity of Rio de Janeiro that are preserved in various museums. And in favorable summers it visits the northern margin of its range in such numbers that one experienced observer has reported capturing up to 50 specimens in a season and seeing a school of hundreds passing his yacht about three feet below the surface of the water in the vicinity of Cape Lookout, North Carolina.[87]

Relation to Man. Wounds caused by the tail spines of the Spotted Duck-billed Ray are described as excruciatingly painful and as sometimes having serious results such as the loss of a leg or arm, death sometimes resulting. Thus we read that in Malayan waters they "cause severe symptoms of poisoning. Violent pain and faintness precede rapid local swelling about the puncture which quickly becomes the seat of violent inflammation and perhaps gangrene."[88] It is probable that their spines are rendered venomous by glandular tissue similar to that of the dasyatids (p. 336), though this is not definitely established. But fishermen do not fear them as much as other Sting Rays, partly because they do not resist capture as vigorously as the dasyatids, but chiefly because they cannot lash their spines as violently, since these are borne close to the root of the tail. They are of some commercial importance of a negative sort because of their habit of preying upon shellfish beds, especially those of the pearl oyster in Ceylon waters. On the other hand, they are used for human food to some extent in the West Indies, in the towns along the Gulf of Campeche, Mexico, along the coasts of India, among the East Indies, in the Hawaiian Islands, and perhaps among other island groups of the Pacific.

Range. Tropical and warm temperate belts of the Atlantic, from Angola (about Lat. 11° S) to the vicinity of Cape Verde in the east; from southern Brazil to North Carolina and straying as far north as Chesapeake Bay in the west; also widespread in the corresponding thermal belts on both sides of the Pacific including its island groups, in the East Indian-Philippine-Australian region, in the Indian Ocean around India, and along East Africa to Knysna in about Lat. 34° S, a little east of C. Agulhas,[89] also in the Red Sea.

Occurrence in the Western Atlantic. Aetobatus narinari occurs generally along the subtropical and tropical Atlantic and Caribbean shores of South America, being recorded definitely from the vicinity of Santos (Praia de San Vincente), Rio de Janeiro, Bahia, and Pernambuco in Brazil; French, British, and Dutch Guianas; Trinidad; Venezuela;

87. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 338; Proc. biol. Soc. Wash., *28*, 1915: 94.

88. Gimlette (Malay Poisons, 1923: 120, quoted from Gudger [Bull. Hist. Med., *14*, 1943: 482]). See also Coles (Bull. Amer. Mus. nat. Hist., 28, 1910: 340) for a firsthand account of a wound which he suffered.

89. Reported south to Knysna by Smith (Sea Fish. S. Afr., 1949: 68).

Honduras; and Gulf of Campeche.[90] Its range includes the West Indian region in general,[91] as well as the waters around southern Florida northward on the east to Biscayne Bay. It is characterized as "often seen" in Bermuda waters, both in Castle Harbor and offshore.[92] It is not recorded from the east coast of Florida north of Biscayne Bay, from Georgia, or from South Carolina, but it appears in the vicinity of Cape Beaufort, North Carolina in considerable numbers, at least in some summers, and in the enclosed waters (if less commonly) in the vicinity of Beaufort. It has been described as reaching Chesapeake Bay,[93] though no recent evidence of its presence that far north has come to hand.

In the Gulf of Mexico it has been recorded on various occasions from: Boca Grande, Lemon Bay near Englewood, Sarasota, Tampa, and Cedar Keys along the west coast of Florida; from Main Pass and Barataria Bay, Louisiana, and in the Gulf three miles out from the latter; also from the Gulf of Campeche; hence it is to be expected anywhere along the western shore of the Gulf.

Synonyms[94] and Atlantic References[95]:

Raja narinari Euphrasen, Handl. K. Vetensk. Akad., *11*, 1790: 217, pl. 10 (descr., ill., St. Bartholomew I., W. Indies);[96] Walbaum, P. Artedi Genera Pisc. Emend. Ichthyol., 3, 1792: 528 (descr., color, by ref. to Euphrasen, 1790); Bloch and Schneider, Syst. Ichthyol., 1801: 361 (descr., color, util., Amer. seas).

Raie aigle (in part), Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: pl. 6, fig. 2 (ill., ident. by subrostral fin and color pattern; not descr. p. 104, which is of *Myliobatis*).

Raie de Commerson, Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 112 (descr., ident. by color pattern and position of dorsal fin and tail spines, Isle de France [Mauritius] and Madagascar); Lacépède, in Sonnini, Hist. Nat. Poiss., *3*, 1801–1802: 199 (same as Lacépède, 1798).

Raie narinari, Sonnini, Hist. Nat. Poiss., *3*, 1801–1802: 201 (color, Brazil and Guiana).

Eel Tenkee, Russell, Fish. Coromandel, *1*, 1803: 5, pl. 8 (ill., ident. by subrostral fin and color pattern, Coromandel Coast, India).[97]

Raja guttata Shaw, Gen. Zool., *5* (2), 1804: 285, pl. 142 (descr., ill., based on the Eel Tenkee of Russell, 1803, Indian and African seas, Madagascar, Coromandel, Brazil).

Aetobatus narinari Blainville, Bull. Soc. philom. Paris, 1816: 112; also, J. Physique, *83*, 1816: 262 (name only); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 88 (descr., tropical Atlant. coast

90. See Study Material, p. 453.
91. Definite West Indian records are Trinidad, Barbados, St. Bartholomew, Turks Island, Haiti, Jamaica, Puerto Rico and Culebra Island; both coasts of Cuba, where many are seined (personal communication from Luis Howell-Rivero), and Bimini, Bahamas, where we saw several in the local aquarium.
92. Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 30.
93. It seems likely that repeated reports of it as ranging northward to Virginia refer back to Uhler and Lugger's (Rep. Comm. Fish. Md., 1876: 184) statement that "it enters Chesapeake Bay from the ocean and is caught in seines near Norfolk, Virginia."
94. Besides the synonyms listed below, Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 473, 474) includes *Myliobatis tenuicaudatus* Hector (Trans. Proc. N. Z. Inst., *9*, 1877: 468, pl. 10), and the Ray referred to by Kent (Gt. Barrier Reef, 1893: 306, pl. 48, fig. 2) as *Dicerobatis erejoodo* (Cuvier). But Hector's illustrations show that the first of these has several series of teeth in each jaw, while it is obvious from Kent's photographs that the latter was the Devil Ray *Mobula diabola* (Shaw) 1804.
95. See Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 272, *Stoasodon narinari*) for references for the eastern Pacific, and Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 470) and Marchand (Bull. Fish. biol. Surv. S. Afr., 2, 1935: 60) for references from other parts of the Pacific, the Australian-Philippine-East Indian region, the Indian Ocean, and the Red Sea.
96. Bloch's (Hist. Nat. Poiss., *9*, 1786: 36) use of narinari as the vernacular name for a Brazilian *Myliobatis* does not invalidate Euphrasen's (1790) subsequent choice of it as the specific name for the Spotted Duck-billed Ray.
97. "Raja ocellata; capite magno, exerto; . . ." Most of the scientific appellations employed by Russell were polynomial; such of them as were binomial were so only accidentally, therefore they are not to be taken into account.

north to Virginia); Rep. U. S. Comm. Fish. (1895), 1896: 224 (listed, Atlant. Coast of N. Amer. north to Virginia); Jordan and Rutter, Proc. Acad. nat. Sci. Philad. [49], 1897: 93 (listed, Jamaica); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 50 (listed, Florida); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 16, figs. 37, 37a (ills.); Evermann and Marsh, Bull. U. S. Fish Comm., *20*, 1902: 67, figs. 4, 5 (descr., color, size, ills., Culebra I., Puerto Rico); Gregg, Where to Catch Fish E. Coast Fla., 1902: 26 (descr., ill., Biscayne Bay, Florida); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 81 (listed, Rio de Janeiro); Hargreaves, Fish. Brit. Guiana, 1904: 15 (ill., Brit. Guiana); Jordan, Guide to Study Fish., *1*, 1905: 557, 558, fig. 349; teeth, color, range, ill. after Jordan and Evermann, 1900); Bean, Field Mus. Publ. Zool., 7 (2), 1906: 30 (listed, Bermuda); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 192, 211 (descr., refs., Brazil); Smith, N. C. geol. econ. Surv., *2*, 1907: 46 (size, ill., Beaufort, N. Carolina); Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 338 (nos., habits, diet, leaping, birth of young, wounds by tail spines, C. Lookout, N. Carolina); Gudger, Amer. Nat., *44*, 1910: 399 (C. Lookout and Beaufort, N. Carolina); Science, N. S. *31*, 1910: 917 (teeth used for digging); Vincent, Sea Fish. Trinidad, 1910: 53 (listed, Trinidad); Gudger, Proc. biol. Soc. Wash., *25*, 1912: 150 (color, size, weight, strength, C. Lookout and Beaufort, N. Carolina); Coles, Bull. Amer. Mus. nat. Hist., 32, 1913: 30 (sounds emitted, color, size, embryos, photos, C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 441, pl. 49, figs. 1–3, pl. 54, fig. 4, pl. 55, fig. 9, pl. 57, fig. 4, pl. 73, fig. 4 (descr., ills., teeth, heart, skel.); Gudger, Yearb. Carneg. Instn., 12, 1913: 177 (listed, Key West, Florida); Proc. biol. Soc. Wash., 26, 1913: 101 (color, size, weight); Pap. Tortugas Lab., *6* (12), 1914: 243, pls. 1–9 (hist., descr., color, size, breeding, wounds by tail spines, habits, refs., range, photos); Radcliffe, Trans. Amer. Fish. Soc., *44*, 1914: 38 (teeth, stom. contents, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (size, nos., C. Lookout, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *67*, 1915: 245 (listed, Boca Grande, Florida), 521 (listed, Trinidad, W. Indies); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 278, pl. 47, fig. 3, pl. 48, fig. 2 (color, habits, teeth, N. Carolina); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Praia de St. Vincente, Brazil); Nichols, Bull. Amer. Mus. nat. Hist., *44*, 1921: 22 (listed, Turks I., W. Indies); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 89 (descr., color); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 47 (same as in Ribeiro, 1907); Beebe and Tee-Van, Zoologica, N.Y., *10*, 1928: 31 (color, Haiti); Borodin, Bull. Vanderbilt Oceanogr. (Mar.) Mus., *1* (1), 1928: 5 (listed, W. Indies); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 70 (descr., color, photo, Chesapeake Bay); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 38 (diagn., ill.); Jordan, Manual Vert. Anim. NE U. S., 1929: 19 (diagn.); Nichols, Sci. Surv. Puerto Rico, N.Y. Acad. Sci., *10* (2), 1929: 188 (descr., habits, size at birth, Puerto Rico); Gowanloch, Bull. La. Conserv. Dep., 21, 1932: 85–86 (teeth, diet, size, Barataria Bay, Louisiana); Gudger, Sci. Mon. N.Y., *34*, 1932: 404 (descr., tail spine in Hammerhead Shark); Copeia, 1933: 186 (no. tail spines, size, Key West, Florida); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 137 (descr., ill., refs., range); Norman and Fraser, Giant Fishes, 1937: 78, pl. 3 (habits, depredation on pearl oyster beds, range, ill.); White, Bull. Amer. Mus. nat. Hist., *74*, 1937: 91 (no. heart valves, after Garman 1913); Butsch, J. Barbados Mus. hist. Soc., *7* (1), 1939: 18 (Barbados; not seen); Longley and Hildebrand, Pap. Tortugas Lab., Publ. Carneg. Instn., *34*, 1941: 4 (size, Tortugas, Florida); Fowler, Fish Culturist, *21*, 1942: 66 (listed, Cuba); Arch. Zool. Estad. São Paulo, *3*, 1942: 132 (listed, Brazil); Röhl, Fauna Descript. Venezuela, 1942: 369 (Venezuela; not seen); Gudger, Bull. Hist. Med., *14*, 1943: 469, fig. 1, 481 (ill., wounds by tail spines, nos. tail spines, Beaufort, N. Carolina); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 433, 456 (listed, Bahamas, Jamaica); Monogr. Acad. nat. Sci. Philad., 7, 1945: 100, 161 (listed, N. Carolina, S. Carolina); Schultz, Proc. U. S. nat. Mus., *99*, 1949: 32 (Venezuela).

Myliobatis narinari Cuvier, Règne Anim., *2*, 1817: 138, footnote 1 (mentioned); Règne Anim., *2*, 1829: 401, footnote 2 (same as Cuvier, 1817); Valenciennes, in Cuvier, Règne Anim., ed. illustr. Poiss., 1838–1843: pl. 118, fig. 4a (ill. lower dental plate).

Raia quinqueaculeata Quoy and Gaimard, Voy. Uranie, Zool., 1824: 200, pl. 43, fig. 3 (descr., color, ill., no. tail spines, Guam, trop. Pacif.).

Myliobatis eeltenkee Rüppell, Neue Wirbelt. Abyssinia, Fische, 1835: 70, pl. 19, fig. 3 (ill. teeth, Abyssinia).

Aetobatis indica Swainson, Nat. Hist. Fish., Amphib., Rept., *2*, 1839: 321 (name, by ref. to Russell [Fish. Coromandel, 1803: pl. 8]).

Myliobatis narinari (*Aetobatis*) Owen, Odontogr., 1840–1845: 46–47, pl 25, figs. 3, 4 (teeth, use of lower dental plate for digging).

Myliobatis macroptera McClelland, Calcutta J. nat. Hist., *1*, 1841: 60, pl. 2, fig. 1 (descr. snout, ill., Bengal).

Aetobatis narinari Müller and Henle, Plagiost., 1841: 179, 198 (descr., meas., color, Surinam [Dutch Guiana]); Agassiz, Poiss. Foss., *3*, 1843: 326 (Brazil);[98] Gray, List Fish. Brit. Mus., 1, 1851: 130 (refs., Indian Ocean, Sumatra); Duméril, Arch. Mus. Hist. nat. Paris, *10*, 1861: 242, pl. 20, fig. 1 (ill. head, trop. W. Afr.); Hist. Nat. Poiss., *1*, 1865: 641 (descr., color, size, Brazil, Indian seas, Red Sea); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 492 (descr., Jamaica, Bahia, but *Raja flagellum* Bloch and Schneider 1801 also included among refs.); Goode, Bull. U. S. nat. Mus., 5, 1876: 73, 76 (listed, Bermuda); Uhler and Lugger, Rep. Comm. Fish. Md., ed. 1, 1876: 184; ed. 2, 1876: 158 (listed, Chesapeake Bay); Yarrow, Proc. Acad. nat. Sci. Philad., *29*, 1877: 216 (size, nos., Beaufort, N. Carolina); Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (listed, E. Florida); Günther, Guide to Study Fish., 1880: 345 (size, color, range, ill.); Challenger Rep., *1* (6), 1880: 8 (listed, Bermuda); Poey, in Gundlach, An. Soc. esp. Hist. nat., *10*, 1881: 349 (listed, Puerto Rico, Cuba, Jamaica, Brazil, E. Indies); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 50 (descr., color, range); Stahl, Fauna Puerto Rico, 1883: 81, 167 (Puerto Rico; not seen); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 160 (listed, S. Carolina); Osorio, J. Sci. math. phys. nat. Lisboa, (2) *2* (5), 1890: 60 (listed, Benguela, Angola, W. Afr.); J. Sci. math. phys. nat. Lisboa, (2) *5*, 1898: 201 (listed, Angola); Metzelaar, Trop. Atlant. Visschen, 1919: 200 (listed, Atlant.); Nigrelli, Amer. Mus. Novit., 996, 1938: 10 (cestode parasites); Gemeroy, Zoologica N.Y., *28* (3), 1943: 113 (blood serum).

Raja edentula Lichtenstein, Descr. Anim. Observ. I. R. Forster, 1844: 227, 256 (substitution for *narinari* Müller and Henle 1841, listed, Tahiti, Tanna).

La Mourine narinari, Cuvier and Duvernoy, Leçons d'Anat. Comp., *8*, 1846: 93 (descr. wall of oviduct).

Stoasodon narinari Cantor, J. Asiat. Soc. Beng., *18*, 1849: 1416 (descr., color, meas., Malay Peninsula); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 879 (*Stoasodon* Cantor 1849 subst. for *Aetobatis* Müller and Henle 1841); Jordan, Proc. U. S. nat. Mus., *9*, 1886: 26 (listed, Beaufort, N. Carolina); Jenkins, Johns Hopkins Univ. Stud. Biol., *4*, 1887: 84 (listed, Beaufort, N. Carolina); Henshall, Bull. U. S. Fish Comm., *9*, 1891: 384 (color, Lemon Bay, Florida); Bull. U. S. Fish Comm., *14*, 1895: 210 (size, color, W. Florida); Smith, Rep. U. S. Comm. Fish. (1895), 1896: 175 (listed, Biscayne Bay, Florida); Jordan and Thompson, Bull. U. S. Bur. Fish., *24*, 1905: 232 (habits, Tortugas, Florida); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 30 (listed, Atlant. Coast U. S. to Virginia; Pacif., Gulf of Calif. to Panama); Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 30 (size, ill., Bermuda); Gowanloch, Bull. La. Conserv. Dep., 1933: 237, 238 (descr. teeth, ill., Barataria Bay, Louisiana); Gunter, Copeia, 1935: 39 (listed, Barataria Bay, Louisiana and Gulf of Mexico); Bere, Amer. Midl. Nat., *17*, 1936: 582 (copepod parasites, Lemon Bay, W. Florida); Gunter, Amer. Midl. Nat., *26*, 1941: 196 (nos., Louisiana Coast); Amer. Midl. Nat., *28*, 1942: 318 (listed, fresh water, Siam).

Goniobatis meleagris Agassiz, Proc. Boston Soc. nat. Hist., *6*, 1859: 385 (descr., Sandwich [Hawaiian] Islands).

Aetobatis latirostris Duméril, Arch. Mus. Hist. nat. Paris, *10*, 1861: 242, pl. 20, fig. 1 (descr., ill., Gaboon, W. Africa); Hist. Nat. Poiss., *1*, 1865: 643 (descr., Gaboon, W. Africa); Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 56; Faune Senegambie, 1, Poiss., 1883–1885: 33 (listed, Senegal); Ehrenbaum, Fischerbote, *6*, 1914: 407 (Cameroon; not seen); Küstenfische Westafrika, 1915: 74 (ill., W. Africa; not seen); Metzelaar, Trop. Atlant. Visschen, 1919: 200 (Senegal by ref. to Rochebrune, 1882, Cameroon by ref. to Ehrenbaum, 1914); Monod, Faune Colon, Franc., 1927: 650 (W. Africa; not seen).

Aetobatis laticeps Gill, Ann. New York Lyc., *8*, 1865: 137 (descr., teeth, color, W. Coast Amer.).

Stoasodon laticeps Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 879 (listed, W. Coast Mexico).

Aetobates narinari Sauvage, in Grandidier, Hist. Phys. Nat. Madagascar, *16*, Poiss., 1891: 510 (listed, Madagascar).

Eagle Ray, Mitchell-Hedges, Battles with monsters of the sea, 1937: 224–225 (photos, female 7 ft. 5 in. wide and young, off Honduras).

Aetobatus punctatus Whitley, Fish. Aust., 1, 1940: 221, 224, 225, figs. 251, 257 (descr., teeth, ill., Australia).

Probable Synonyms:

Aetobatis guttatus Annandale, Mem. Indian Mus., *2*, 1909: 56 (ident. doubtful because of color pattern, Bay of Bengal).

Aetobatus ocellatus Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 442 (no diff. from *narinari* suggested by brief descr., specimen apparently not extant; Indian Ocean).

98. The upper and lower teeth are reversed in the explanation of the illustrations.

Doubtful Synonyms:

Myliobatis ocellatus Kuhl, in van Hasselt, Allg. Konst. en Letterbode Haarlem, 1, 1823 (not seen); Bull. Sci. Nat. Ferussac, (2) *2*, 1824: 90 (Java).

Aetobatus ocellatus Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 475 (specimen without tail spine, South Sea Islands; see discussion, p. 452).

Not *Myliobatis punctatus* Miklucho-Maclay and Macleay, Proc. Linn. Soc. N. S. W., *10*, 1886: 675, 676, pl. 46, figs. 1–6 (genus *Myliobatis* because dental plates descr. as of "many longitudinal rows of teeth.").

Family RHINOPTERIDAE

Cow-nosed Rays

Characters. The subrostral fin, extending forward from the lower surface of the head, is deeply incised in the midline, thus forming two distinct lobes that are, however, continuous with each other basally. The anterior contour of the cranium is moderately concave, so that the front of the head is definitely bilobed in some species though hardly so in others. Floor and roof of mouth without fleshy papillae. Pelvis strongly arched, with median process directed forward. Posterior face of hyoid arch and each face of first to fourth gill arches, as well as anterior face of fifth gill arch with a series of narrow and close-set transverse folds, succeeded inward by about half as many shorter and broader folds; inner edge of each gill arch with about 5–6 much larger fleshy papillae (Fig. 80). Characters otherwise as in the Myliobatidae (p. 433).

Remarks. The distinctions between the Cow-nosed Rays (Rhinopteridae) and the Eagle Rays (Myliobatidae) are so slight that some recent authors unite the two groups in a single family,[1] but others regard them as distinct subfamilies[2] or families.[3] The latter course is followed here.

Developmental Stages. Development is ovoviviparous. After the yolk is absorbed the embryos are nourished by secretions that are poured out by the villi with which the inner wall of the uterus is densely clothed and that are described as giving off a red extract in formalin or in alcohol.[4]

Genera. The various representatives of the group from different parts of the world resemble one another so closely that they are grouped by common consent in the single genus, *Rhinoptera* Cuvier 1829.

Genus *Rhinoptera* Cuvier 1829[5]

Rhinoptera Cuvier, Règne Anim., *2*, 1829: 401; type species, *Myliobatis marginata* Etienne G. St.-Hilaire (Descr. Egypte, *1*, 1817,[6] pl. 25, figs. 3–4); Isidore G. St.-Hilaire (Descr. Egypte, *1*, 1827: 334). Eastern Mediterranean.

1. Rey, Fauna Iberica, Peces, *1*, 1928: 640, as Myliobatidae; Whitley, Fish. Aust., *1*, 1940: 220, as Aetobatidae.
2. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1940: 458, Myliobatinae and Rhinopterinae.
3. Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 259, Myliobatidae and Rhinopteridae; Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 273, Aetobatidae and Rhinopteridae.
4. Described for *Rhinoptera bonasus* by Coles (Bull. Amer. Mus. nat. Hist., *32*, 1913: 32).
5. The generic name *Rhinoptera* was proposed by van Hasselt, first as *Rhenoptera* (Allg. Konst. en Letterbode Haarlem, *1*, 1823: 316, not seen) and a year later as *Rhinoptera* (Bull. Sci. Nat. Ferrusac, [2] *2*, 1824: 90), without a statement as to its distinctive characters, except that it is separable from *Cephaloptera*. *Rhinoptera* must therefore date from Cuvier 1829, who first applied it to a recognizable Ray.
6. According to Isidore Geoffrey St.-Hilaire (Vie, Travaux .... Etienne Geoffrey St.-Hilaire, 1847: 425), the ten

Generic Synonyms:

Myliobatis G. St.-Hilaire, Descr. Egypte, 1817: pl. 25, figs. 3–4; *1*, 1827: 334; for *M. marginata* St.-Hilaire.

Zygobatis Agassiz, Poiss. Foss., *3*, 1838: 79, also Poiss. Foss., *3*, Atlas, 1835: pl. D, fig. 8, not named; type species, *Myliobatis jussieui* Cuvier 1829.

Zygobates Agassiz, Poiss. Foss., *3*, 1843: 328; emended spelling for *Zygobatis* Agassiz 1838.

Trikeras Harless, Abh. bayer. Akad. Wiss. (1847–1849), Math. Phys. Kl., *5*, 1850: 843, pls. 23–25; no diagnosis or species, but ill. of teeth probably of *Myliobatis marginata* G. St.-Hilaire 1817, 1827.

Mylorhina Gill, Ann. New York Lyc., *8*, 1865: 136; type species, *Rhinoptera lalandii* Müller and Henle 1841.

Micromesus Gill, Ann. New York Lyc., *8*, 1865: 136; type species, *Rhinoptera adspersa* Müller and Henle 1841.

Trycera Doderlein, Man. Ittiol. Medit., 2, 1884: 242 (Koch MS.); type species, *Myliobatis typica* (Koch MS.), equals *M. marginata* G. St.-Hilaire 1817, 1827.

Rhenoptera Whitley, Fish. Aust., *1*, 1940: 221, 225; for *Rhinoptera neglecta* Ogilby 1912.

Not *Myliobatis* Cuvier 1817, which see, p. 435.

Generic Characters. Tail with one or more spear-tipped spines with serrate edges close behind dorsal fin. Anterior contour of cranium noticeably concave in western Atlantic species but hardly so in some others.[7] Subrostral fin soft, bilobed, arising from lower surface of head below level of pectorals proper considerably posterior to anterior margin of cranium and extending forward as a shelf; radial cartilages interrupted for a short distance opposite corners of mouth, those supporting subrostral fin much more slender than those of main portions of pectorals. Dorsal fin originating anterior to axils of pelvics. Free posterior margin of transverse curtain on roof of mouth finely fringed with short lobelets; fold overlapping upper dental plate with several irregular rows of short rounded lobes but without longer papillae; floor of mouth without papillae. Teeth normally in seven or more series in each jaw, but anomalies in this respect are not uncommon. Skin, except for tail spines, entirely smooth in both sexes in some species but more or less rough with small prickles on stellate bases in others. Characters otherwise those of family.

Size. These Rays are of medium size; the maximum measured breadth reported is about seven feet, though larger ones are said to have been seen (p. 472).

Habits. The Cow-nosed Rays, like the Eagle and Spotted Duck-billed Rays, subsist mainly on oysters, clams, and other large bivalve mollusks, and they have been seen stirring up clouds of mud and sand from the bottom while rooting for them (p. 474). They also prey to some extent on the larger crustacea (p. 473). Beyond this practically nothing is known of their way of life. They are seen most often in shoal water, even in the surf, occasionally in large schools. Like other Rays, they progress by flapping motions of their expanded pectorals. Sometimes they jump clear of the surface.[8] They are of no economic importance.

Range. Coastal waters in tropical and warm-temperate latitudes of all oceans; Atlantic Coast of southern Spain and Mediterranean to equatorial West Africa in the

plates of the Histoire naturelle des poissons de la mer Rouge et de la Mediterranaee, of which pl. 25 was one, appeared in 1817, following the publication of the ten plates of the Poissons du Nil in 1808.

7. It is described and pictured as nearly straight in *Rhinoptera peli* Bleeker 1863 from tropical West Africa; see p. 468, footnote 15.

8. They are described as so doing by Evermann and Jenkins (Proc. U. S. nat. Mus., *14*, 1891: 130), who saw many in the surf in the Gulf of California near Guaymas.

eastern Atlantic; southern New England to southern Brazil in the western Atlantic; Gulf of California to Galapagos Islands; Australia (Queensland); East Indies; Philippines, China; Gulf of Siam; Malay Peninsula; Ceylon; India; northern Arabian Sea; and Gulf of Oman.

Species. The only characters that have proved useful for specific definition are the numbers of teeth and their shapes, but the degree of roughness of the skin may prove diagnostic also.[9] Thus, a disc uniformly prickly above characterizes one of the Indo-Pacific forms (*R. adspersa* Müller and Henle 1841), whereas most of its genus mates are naked. But this difference cannot be used as an alternative Key character for the genus as a whole until the situation in this respect is known for the Australian *R. neglecta* Ogilby 1912 and for the East Atlantic *R. marginata* (G. St.-Hilaire) 1817, 1827.[10]

Three species of Cow-nosed Rays have commonly been recognized in the western Atlantic: *R. bonasus* (Mitchill) 1815 from the Atlantic Coast of the United States and *R. lalandii* Müller and Henle 1841 from Brazil, with the teeth normally in seven series in each jaw; *R. brasiliensis* Müller and Henle 1841,[11] with the teeth in nine series or more. However, our own examination of the series listed on p. 469, including specimens taken from near the type localities of *R. bonasus* and of *R. lalandii*, has failed to reveal any differences in teeth or in any other features that could be made the basis of specific separation between these two. Therefore they are united here under the older name *R. bonasus* (Mitchill) 1815).[12] It proves further that the separation between *R. bonasus*, normally with seven series of teeth, and *R. brasiliensis*, with nine or more, is not sharp-cut, abnormal specimens having been seen with seven above and eight below,[13] others with nine above and only eight below.[14] It seems allowable, however, to retain the specific name *brasiliensis* as distinct from *bonasus*, at least until the numbers of half-grown specimens or larger of each that have been studied are sufficient to give significant statistical data.

R. marginata (St.-Hilaire) 1817, 1827, of the Mediterranean, a little known species, appears to differ from *R. bonasus* in having (normally) nine series of teeth in each jaw; apparently it differs from *R. brasiliensis* in the fact that its median series of teeth are only about three times as broad (transversely) as long (anteroposteriorly); it may differ from both *R. bonasus* and *R. brasiliensis* by being rough along the median belt of its disc, at least by the time it has grown to a breadth of 18 inches or so (see p. 469, footnote 26).

9. The roughness or smoothness of the skin was used by Duméril (Hist. Nat. Poiss., *1*, 1865: 644) as a primary alternative in his Key to the species of *Rhinoptera* that were then known.
10. *R. marginata* is described by Müller and Henle (Plagiost., 1841: 181) as partially rough above, by Garman as smooth (Mem. Harv. Mus. comp. Zool., *36*, 1913: 446), from a small specimen in each case.
11. Our choice of the specific name *brasiliensis* Müller and Henle 1841 for this species rather than *jussieui* Cuvier 1829, which has been applied commonly to it, rests on the fact that *R. jussieui* was based on a specimen that had only seven series of teeth, not nine, and was from China, not from the Atlantic. See References, p. 480.
12. For accounts and illustrations of abnormal dentition in specimens listed as *R. bonasus* and *R. lalandii*, see Gudger (J. Elisha Mitchell Sci. Soc., 49, 1933: 76, 78, figs. 11–14).
13. Specimen from Newport, Rhode Island; the extra series in the lower jaw is shown in Garman's illustration (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 37, fig. 5).
14. One from North Carolina, pictured by Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: pl. 47, fig. 4) and by Gudger (J. Elisha Mitchell Sci. Soc., *49*, 1933: pl. 77, as *R. quadriloba*); also one from Brazil in our Study Material.

It is an open question whether *R. peli* Bleeker 1862 of tropical West Africa, with nine series of teeth in each jaw, is separable from *R. marginata*, partly because the original descriptions of the two[15] do not give sufficient information and partly because subsequent accounts were not only based on small specimens but are contradictory to some extent.[16] But the anterior contour of the cranium is pictured as so much more deeply concave in the original illustration of *R. marginata* than in that of *R. peli* that we retain both species provisionally.

Recent authors recognize six species in the Pacific and Indian oceans, with tributary seas:[17] *R. steindachneri* Evermann and Jenkins 1892[18] from the west coast of Central America and *R. javanica* Müller and Henle 1841[19] of southern China, the East Indies, India, and Ceylon, both with seven series of teeth; *R. adspersa* Müller and Henle 1841[20] from the Malay Peninsula and India, *R. jayakari* Boulenger 1895[21] from Arabia, *R. neglecta* Ogilby 1912[22] from Australia, and *R. sewelli* Misra 1947[23] from India, all with nine series of teeth. The exact relationships of these to one another and to Atlantic species with corresponding numbers of teeth have not been determined.[24]

Key to Atlantic Species[25]

1 a. Teeth normally in seven series in each jaw, occasionally only six series or as many as eight. *bonasus* Mitchill 1815, p. 469.

1 b. Teeth normally in at least nine series in each jaw, perhaps occasionally only eight or as many as ten.

2 a. Upper teeth of median series five times as wide (transversely) as long (anteroposteriorly). *brasiliensis* Müller and Henle 1841, p. 477.

2 b. Upper teeth of median series not more than about three times as broad (transversely) as long (anteroposteriorly).

3 a. Anterior contour of cranium conspicuously concave; upper teeth of

15. *Myliobatis marginata* Etienne G. St.-Hilaire (Descr. Egypte, *1*, Atlas, 1817: pl. 25, figs. 3–4) and Isidore G. St.-Hilaire (Descr. Egypte, *1*, 1827: 334); *R. peli* Bleeker (Nat. Verh. Holl. Maatsch. Wetensch., [2] *18*, 1863: 18, pl. 1).

16. Duméril (Hist. Nat. Poiss., *1*, 1865: 647) describes the teeth of the median series for *R. marginata*, without qualification, as much larger than those of the next outward rows. But Bleeker (Nat. Verh. Holl. Maatsch. Wetensch., [2] *18*, 1863: pl. 1) pictures them thus only for the upper jaw for *R. peli*, not for the lower jaw.

17. For recent accounts of the Indo-Pacific representatives of *Rhinoptera*, with references, see Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 273) for *R. steindachneri*, Mexico and Galapagos Is.; Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 476–478), for species from China, the Australasian region, Indian Ocean, and Arabia; Misra (Rec. Indian Mus., *44* [4], 1947: 361, pl. 1) for *R. sewelli*, India.

18. Proc. U. S. nat. Mus., *14*, 1892: 130, pl. 1, fig. 1.

19. Plagiost., 1841: 182, pl. 58.

20. Plagiost., 1841: 183.

21. Ann. Mag. nat. Hist., (6) *15*, 1895: 141.

22. Mem. Qd. Mus., *1*, 1912: 32.

23. Rec. Indian Mus., *44* (4), 1947: 361, pl. 1.

24. *R. polyodon* Günther (Cat. Fish. Brit. Mus., *8*, 1870: 495), from an unknown locality, with 15 series of teeth above and 14 below (jaws only), and *R. encenadae* Smith (Proc. U. S. nat. Mus., *9*, 1886: 220), from Lower California, with 14 series in the lower dental plate and differing in size and shape on the two sides (upper dental plate not known) appear to have been based on abnormalities; the latter is apparently a *Myliobatis californicus* (personal communication from C. L. Hubbs).

25. It may not be possible to identify the embryos, for their distinctive tooth characters may not be sufficiently established until birth.

series next on either side to median series hardly narrower transversely than those of median series.[26]

marginata (Etienne G. St.-Hilaire) 1817, (Isidore G. St.-Hilaire) 1827.
Mediterranean and neighboring Atlantic.

3b. Anterior contour of cranium hardly concave; upper teeth of series next on either side to median series considerably narrower transversely than those of median series.[27] *peli* Bleeker 1863.
Tropical West Africa.

Rhinoptera bonasus (Mitchill) 1815

Figures 107, 108

Study Material. Fifteen specimens, 238 to 250 mm (embryo) and 365 (newborn) to 774 mm broad, and the head of a larger specimen about 1,500 mm broad, from Woods Hole, Massachusetts; Newport, Rhode Island; lower Chesapeake Bay; Pensacola, Florida; Main Pass, Louisiana; near Havana, Cuba; and Rio de Janeiro, Brazil; in Harvard Museum of Comparative Zoology and in the U. S. National Museum.

Distinctive Characters. The indented anterior contour of its cranium, with the conspicuously bilobed subrostral fin, marks this Ray off at a glance from all of its relatives of the western Atlantic except for *Rhinoptera brasiliensis*. *R. bonasus* resembles *R. brasiliensis* so closely in appearance and in bodily proportions that the two appear not to be separable except by the number of teeth, of which there are normally only seven series in each jaw in *R. bonasus* but nine in *R. brasiliensis*. Specimens with fewer series of teeth or more and with less regular arrangement than normal are seen occasionally, bridging the gap more or less completely between the two species.[28] While the teeth of the median series average shorter (anteroposteriorly) relative to their breadths (transversely) in *R. brasiliensis* than in *R. bonasus*, the two species intergrade in this respect even within the small series that we have studied.

Description. Proportional dimensions in per cent of extreme breadth of disc. Female, 540 mm broad, and male, 774 mm broad, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., Nos. 535 and 374 respectively).

Disc: vertical length 55.0, 57.5.

Snout length: in front of orbits 1.9, 1.2; in front of mouth 9.8, 10.3.

Orbits: horizontal diameter 4.5, 4.4; distance between 10.7, 10.9.

Spiracles: length 3.9, 3.2; distance between 14.6, 14.6.

26. The tooth character used here as alternative between *R. peli* and *R. marginata* is derived from Bleeker's (Nat. Verh. Holl. Maatsch. Wetensch., [2] *18*, 1863: pl. 1) original illustration of *R. peli* (description confusing) and from Duméril's (Hist. Nat. Poiss., 1, 1865: 645) account of *R. marginata*. Garman's illustrations of the teeth of *R. marginata* (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 48, fig. 4) were of an embryo only 220 mm wide with the scar of the yolk stalk still open, and from an unknown locality. It may not have come from the Atlantic.

27. See p. 468, footnote 16.

28. Our Study Material includes a *R. bonasus* from Rio de Janeiro, Brazil that has only six series and a *R. brasiliensis* that has one of the lateral series suppressed on one side of the mouth in each jaw; but the presence of an extra series on the other side of each jaw maintains the normal number (nine). Another abnormal specimen, with nine series above but only eight below, has been reported from North Carolina (Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 279, pl. 47, fig. 4).

Mouth: breadth 8.7, 7.8.
Exposed nostrils: distance between inner ends 7.0, 7.1.
Gill openings: lengths, 1st 2.4, 2.2; 3rd 2.7, 2.3; 5th 1.9, 1.9; distance between inner ends, 1st 16.6, 15.2; 5th 10.9, 10.6.
Dorsal fin: vertical height 4.2, 4.8; length of base 5.9, 6.0.
Pelvics: outer margin 9.8, 10.9.
Distance: from tip of snout to center of cloaca 47.1, 47.4; from center of cloaca to origin of caudal spine 10.0, 10.1.

Disc from forehead to level of rear corners of pectorals about 1.7 times as broad as long, the anterior margins nearly straight near head, changing to weakly convex toward outer corners; posterior margins rather deeply concave outwardly; outer and posterior corners narrowly rounded; inner margins weakly convex; main portions of pectorals arising from sides of head close behind eyes, a little below level of latter. Axis of greatest breadth about 70 % of distance rearward from forehead toward axils of pectorals. Tail moderately stout anterior to spine, but slender thence rearward, tapering to lash-like tip, round to oval in cross section, without fold either above or below; its length from center of cloaca about 2.8 times as great as length of body from cloaca to forehead in small specimens, about twice as long as body in larger ones.

One tail spine or two,[29] the origin of the first (if there are two) immediately posterior to base of dorsal; free portion of longer spine (second in cases seen) about half as long as anterior margin of pelvic fin; the anterior spine varying in length from so short that its tip hardly emerges from skin to nearly as long as posterior spine; marginal teeth with broad bases and sharp tips, curving rearward at an angle of about 45°; 46 teeth on each side on spine of specimen 755 mm broad but only 22 on one of 550 mm.

Skin, apart from tail spines, smooth at all ages so far as known.

Forehead rounded laterally, moderately concave transversely, thus head with subrostral fin appears more or less four-lobed. Median belt of upper surface of crown with a shallow longitudinal trough-like depression from level of eyes rearward about as far as level of rear ends of spiracles, much as in *Myliobatis* (p. 441). Orbits not prominent; eyes close to front of head, approximately circular and noticeably small, their diameter only about $^1/_3$–$^1/_4$ as great as distance between spiracles. Spiracles about level with orbits, close to them and about $^3/_4$–$^4/_5$ as long. Gill openings weakly sinuous; first to fourth between $^1/_3$ and $^1/_4$ as long as distance between exposed nostrils, fifth a little shorter; distance between inner ends of first gills about twice as great as distance between exposed nostrils; distance between inner ends of fifth gills about 65–70 % as great as distance between first gills. Nasal curtain of shape shown in Fig. 107 B, its free margin finely fringed with short, simple, rounded lobelets. Mouth nearly straight, occupying a little more than half the width of head, its distance rearward from front of head a little more than half as great as breadth of head at eyes.

29. One tail spine in four and two in four others of specimens seen; the remaining two complete specimens had lost their spines, leaving only scars.

FIGURE 107. *Rhinoptera bonasus*, immature male, 567 mm wide, from Newport, Rhode Island (Harv. Mus. Comp. Zool., No. 746). *A* Side view of head, about 0.6×. *B* Lower surface of anterior part of head, about 0.6×. *C* Side view of tail, about 0.6×.

Upper and lower dental plates strongly convex anteroposteriorly but only weakly so transversely, the exposed margins usually irregular by loss of a tooth from one series or another; front edges of teeth in front row often more or less damaged, the anterior 2–5 rows of teeth in each jaw worn flat by friction of lowers against uppers. Teeth normally in seven series after birth (for embryonic serial arrangement, see Developmental Stages, p. 473); occasionally six or eight in one jaw or the other,[30] in close-set

30. Seven series both above and below in six United States specimens and in two from Brazil; seven above and eight below in one from the United States and in one from Brazil; and six above and seven below in one from Brazil.

quincunx mosaic; edges of successive teeth in contact but not overlapping; those of median five series hexagonal, those of outermost series on either side pentagonal, those of any supernumerary series tetragonal. Teeth of median series about twice as wide transversely as those of next series outward and 3–5 times as wide as those of outermost series; transverse breadths of teeth of all series about the same in oldest rows as in youngest; some specimens with teeth of all series about as long anteroposteriorly in oldest rows as in youngest, but others with teeth in youngest (most posterior) rows about twice as long as in oldest, with regular gradation from oldest to youngest; 11 to 12 rows exposed and in function simultaneously in upper jaw, 12–13 in lower jaw of large specimens, 7 or 8 in each jaw of smaller ones.

Subrostral fin forming two rounded lobes, one continuous with the other at bottom of deep dividing notch, extending only a little beyond front of forehead from which it is marked off by a deep transverse groove, and traceable rearward about to level of mouth but at a lower level than main portions of pectorals. Dorsal fin with nearly straight anterior margin, its posterior margin abruptly concave basally and prolonged rearward for a short distance in acute triangular form, free from tail; its apex narrowly rounded; its origin about opposite axils of pectorals; its base a little less than half as long as distance between spiracles. Pelvics with anterior and inner margins nearly straight, distal margin evenly and rather strongly convex; corners abruptly rounded; anterior margin nearly as long as distance from origin of pelvic to inner rear corner.

Color. Brownish above, lighter or darker, sometimes of a yellowish tint. Lower surface white or yellowish white, with outer corners of pectorals more or less brownish; some specimens marked both above and below with many narrow obscure dark lines or bands radiating outward from center of disc.[31]

Size. It seems that the breadth at birth is about 14 inches, for an embryo 13 1/2 inches wide has been recorded,[32] while our Study Material includes a Brazilian specimen only a little larger (365 mm or about 14 1/2 in. wide) but probably free living, since it has lost its primary embryonic teeth and all traces of its umbilical scar.

It appears that there is a considerable variation in the size at which sexual maturity is reached, either between individuals of the same geographical locality or those in different parts of its range. Thus, the testes of a male only 26–28 inches wide from North Carolinia waters were greatly enlarged[33] and a female of 24 inches contained embryos,[34] whereas the claspers of a Brazilian male 780 mm wide (about 31 in.) in our Study Material still reach only about halfway along the inner margins of the pelvic fins. Evidence as to the maximum size to which the species ordinarily grows is similarly contradictory. Its describer[35] wrote of it as a "large species," with full-grown specimens weighing about 100 pounds; more recently a well known ichthyologist has stated that some of those observed in Florida were seven feet wide.[36] However, the only sexually

31. A Cuban specimen is so pictured and described by Howell-Rivero (Mem. Soc. cubana Hist. nat., *15*, 1941: 261, pls. 26, 27).
32. Gudger, Amer. Nat., *44*, 1910: 397.
33. Gudger, Proc. biol. Soc. Wash., *26*, 1913: 102.
34. Gudger, Amer. Nat., *44*, 1910: 397.
35. Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 479, 480.
36. Smith, N. C. geol. econ. Surv., *2*, 1907: 47.

mature specimens yet seen were much smaller, as stated above. New Jersey specimens weighed in recent years have ranged from 25 to about 70 pounds.[37]

Developmental Stages. Embryos in late stages of development have the tail spine (embedded in the skin) and resemble their parents closely in general appearance except for somewhat longer tails. The earliest formed teeth, lost before birth or shortly thereafter, are round, loosely spaced, in eight or nine series in 1–3 irregular rows; those formed subsequently, when the embryo is about 220–250 mm broad, are in close

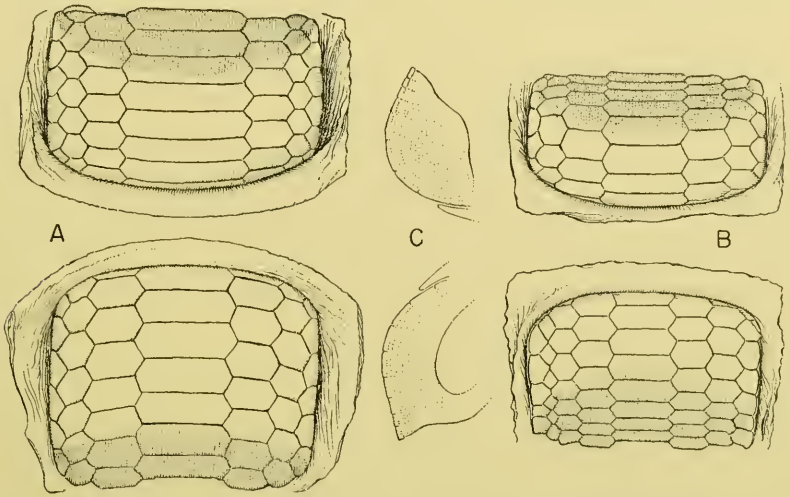

FIGURE 108. *Rhinoptera bonasus*. *A* Upper teeth (above) with front row uppermost, and lower teeth (below) with front row lowermost, from head of specimen about 1,500 mm wide (estimated), from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 535), about 0.7×. *B* Upper teeth (above) with front row uppermost, and lower teeth (below) with front row lowermost, of male, 567 mm wide, from Newport, Rhode Island, with eight series below (Harv. Mus. Comp. Zool., No. 746), about 1×. *C* Cross sections of upper dental plate (above) and of lower dental plate (below) of same, to show curvature.

mosaic from their earliest appearance and are normally in seven series. The unborn young lie in the uteri in pairs, rolled together head to tail. Six have been found in one female, while another gave premature birth to two on capture.

Habits. This Cow-nosed Ray (and probably all members of its genus) feeds chiefly on hard-shelled mollusks, both bivalve and univalve, which it crushes between its powerful dental plates, discarding the broken shells. Razor clams (*Ensis*), oysters, and clams are the chief diet of those that visit North Carolina waters, while the few that reach southern New England feed on clams,[38] large gastropods, lobsters, and crabs. It appears

37. Fowler, Fish Culturist, *6*, 1927: 115; *7*, 1928: 225.

38. There is at least one recorded instance of a Cow-nosed Ray being caught on a hook baited with a clam on the New Jersey Coast; see Fowler (Proc. Acad. nat. Sci. Philad., *69*, 1917: 109).

that they obtain the mollusks chiefly by dislodging them from the bottom by stirring motions of the pectorals, since their subrostral fins are so soft as to make it unlikely that they plough up the mud or sand with these. During a period of early abundance near New York it was recorded that "a shoal of Cow-noses roots up the salt water flats as completely as a drove of hogs would do."[39] They progress rapidly by flapping motions of the pectorals.[40] When feeding on the flats they are described as swimming in compact schools, whether in Florida waters[41] or in the northern part of their range during years of abundance there (p. 474). But this particular Ray has not been reported as leaping above the surface, as has its close relative *Rhinoptera steindachneri* in the Gulf of California (p. 466).

The few dated records for Cow-nosed Rays from Florida have been for winter and spring, though they may be present there the year round; they have been described as present throughout the year in North Carolina waters.[42] But they reach the coast to the northward as warm-season visitors only, the earliest recorded dates for them being July 16 for New Jersey, June 20 for New York, and July 12 for Woods Hole, Massachusetts. September–October is the only period when they have been reported in numbers in northern waters, and the latest dates are October 13–16 for the general vicinity of Woods Hole (including Nantucket) and New Jersey. In North Carolinian waters their young are produced in spring and summer, but in tropical-subtropical latitudes this probably happens throughout the year.

Numerical Abundance. Most of the published reports of the presence of Cow-nosed Rays at one point or another along the United States Coast have been based on few specimens. Near Cape Lookout, North Carolina, for example, where they appear to occur more regularly than anywhere farther north, only 11 were taken during the summer of 1912; more than half a dozen are seldom seen in a season, and during some years none at all, while only 20 were handled near Beaufort, North Carolina by a well known ichthyologist during ten summers' work.[43] For many years previous to 1934 the pound nets in Sandy Hook Bay yielded less than 40 in any one season, and we have heard of only one or two specimens being taken near Woods Hole, Massachusetts, during the past 15 years. But it has long been known that they appear in far greater numbers in some years and in some localities than is ordinarily the case. An incursion of this sort appears to have taken place about 1815, when they were described as visiting the coast near New York "in numerous shoals,"[44] and similar events may have occurred at intervals later in the 19th century for all that is known to the contrary. But it was not until 1902 that another incursion was definitely reported, when 145 of them were taken in a single day in the pounds at Menemsha Bight near Woods Hole, Massachusetts. The third recorded instance was on September 12, 1932 when a single pound net in

39. Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 479.
40. For a vivid account of their mode of swimming as observed in the New York Aquarium, see Gregory (Bull. N. Y. zool. Soc., *38*, 1935: 129).
41. Personal communication from Stewart Springer.
42. Smith, N. C. geol. econ. Surv., *2*, 1907: 47.
43. Gudger, J. Elisha Mitchell Sci. Soc., *49*, 1933: 76.
44. Mitchill, Trans. Lit. philos. Soc. N. Y., *1*, 1815: 479.

Sandy Hook Bay, near New York, yielded 42 specimens.[45] And there is a report of "an immense school of these fishes once seen off Block Island"[46] at the mouth of Long Island Sound (date not stated). The geographic source of these incursions remains to be determined. It is also a question for the future whether such events represent merely wandering schools or temporary peaks of abundance for the species as a whole.

Range. Coastal waters of the western Atlantic, from southern New England to middle Brazil.

Details of Occurrence. Cow-nosed Rays have been reported from localities distributed widely enough[47] to show that they are to be expected anywhere along the east coast of the United States, westward and southward from the elbow of Cape Cod, which appears to mark their northern boundary, to the Gulf coasts of Florida and Louisiana. Also, they appear to be a regular member of the batoid fauna of middle Brazil, whence we have seen specimens (p. 469).[48] But the only reports of them from the intervening belt between middle Brazil and Florida are from British Guiana,[49] Venezuela,[50] and Matanzas on the north coast of Cuba.[51] The Cow-nosed Ray is so easily recognizable that it is not likely to have been overlooked consistently throughout so vast an area. Therefore, present indications are that there are two more or less distinct centers of population for it, the one in United States waters in the northern hemisphere and the other along middle Brazil in the southern hemisphere.

Synonyms and References:

Raja bonasus Mitchill, Trans. Lit. philos. Soc. N.Y., *1*, 1815: 479 (descr., habits, nos., season, weight, near New York).

Raja quadriloba Lesueur, J. Acad. nat. Sci. Philad., *1*, 1817: 44, pl. not numbered (descr., ill., New Jersey).

Rhinoptera quadriloba Cuvier, Règne Anim., *2*, 1829: 401, footnote 4 (ref. to *Raja quadriloba* Lesueur 1817); DeKay, Zool. N.Y., 4, 1842: 375, pl. 66, fig. 217 (diagn., ill. after Lesueur, 1817); Linsley, Amer. J. Sci., *47*, 1844: 79 (listed, Connecticut, New York); Gill, Proc. Acad. nat. Sci. Philad., Addend., 1861: 62 (listed, Atlant. Coast N. Amer.); Duméril, Hist. Nat. Poiss., *1*, 1865: 648 (descr. after Lesueur, 1817 and DeKay 1842); Abbott, in Cook, Geol. N. J., Append. E, 1868: 829 (listed, New Jersey); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 494 (diagn., U. S.); Baird, Rep. U. S. Comm. Fish. (1871–1872), 1873: 826 (listed, Woods Hole, Mass.); Gill, Rep. U. S. Comm. Fish. (1871–1872), 1873: 812 (listed, C. Cod to Florida); Uhler and Lugger, Rep. Comm. Fish. Md., ed. 1, 1876: 184, ed. 2, 1876: 156 (listed, near mouth of Chesapeake Bay); Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (listed, St. Johns R., Florida); Goode and Bean, Proc. U. S. nat. Mus., *2*, 1879: 155 (listed, Pensacola, Florida); Goode and Bean, Proc. U. S. nat. Mus., *5*, 1882: 240 (listed, Gulf of Mexico); Jordan and Gilbert, Bull. U. S. nat. Mus., *16*, 1883: 51 (descr., C. Cod to Florida); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 260 (listed, S. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, N. Atlant. U. S.); Bean, Proc. U. S. nat. Mus., *14*, 1891: 94 (listed, Chesapeake Bay); Henshall, Bull. U. S. Fish Comm., *9*, 1891: 384 (listed, Barnes Sound and C. Sable, Florida); Wilson, Amer. Nat., *34*, 1900: 355 (listed, Beaufort, N. Carolina); Hargreaves, Fish. Brit. Guiana, 1904: 15 (listed, Brit. Guiana); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 444, pl. 37, figs. 1–5 (descr.,

45. Breder and Nigrelli, Copeia, 1934: 194. 46. Tracy, Rep. R. I. Comm. inl. Fish., 1906: 49; 1910: 64.

47. Woods Hole, Massachusetts; Nantucket; Block Island; Narragansett Bay; Connecticut; various localities in the vicinity of New York and along New Jersey; Delaware Bay; Atlantic Coast of Maryland; lower part of Chesapeake Bay; Cape Lookout and vicinity of Beaufort, North Carolina; South Carolina; St. Johns River, Salerno (communication from Stewart Springer), the Keys, Cape Sable, Boca Grande, and Pensacola, Florida; Main Pass, Louisiana.

48. One of the two names (*R. lalandii*) under which it has been reported most often was based on a Brazilian specimen.

49. Hargreaves, Fish. Brit. Guiana, 1904: 15. 50. Schultz, Proc. U. S. nat. Mus., *99*, 1949: 32.

51. Howell-Rivero, Mem. Soc. cubana Hist. nat., *15*, 1941: 259.

ills., Newport, Rhode Island); Radcliffe, Trans. Amer. Fish. Soc., *44*, 1914: 38 (teeth); Linton, Proc. U. S. nat. Mus., *64* (21), 1924: 10 (cestode parasites, Woods Hole, Mass.); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 72 (descr. after Garman, 1913, Nantucket, Woods Hole, Mass.); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43* (1), 1928: 71 (descr., Chesapeake Bay by ref. to Uhler and Lugger, 1876); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 38, 39 (genl., ill.); Gudger, J. Elisha Mitchell Sci. Soc., *49*, 1933: 76 (nos., Beaufort, N. Carolina); Norman and Fraser, Giant Fishes, 1937: 80 (listed, C. Cod to Florida, ill.); Gregory, Bull. N.Y. zool. Soc., 38, 1935: 129 (method of swimming, photos).

Rhinoptera lalandii Müller and Henle, Plagiost., 1841: 182 (descr., meas., Brazil); Duméril, Hist. Nat. Poiss., *1*, 1865: 645 (descr., Brazil); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 494 (descr., Brazil); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 193, 212 (diagn., refs., Brazil); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 445, pl. 48, figs. 5, 6 (descr., ill. teeth, E. coast S. Amer.); Ribeiro, Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 48 (same as Ribeiro, 1907, Brazil); Gudger, J. Elisha Mitchell Sci. Soc., 49, 1933: 77, 80 (abnormal dentition, ills.); Schultz, Proc. U. S. nat. Mus., *99*, 1949: 32 (Venezuela).

Mylorhina lalandii Gill, Ann. New York Lyc., *8*, 1865: 136 (*Rhinoptera lalandii* Müller and Henle 1841, designated as type of *Mylorhina* Gill).

Rhinoptera bonasus Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 90 (descr., C. Cod to Florida); Rep. U. S. Comm. Fish. (1895), 1896: 225 (listed, C. Cod to Florida); Bean, Bull. Amer. Mus. nat. Hist., *9*, 1897: 331 (listed, Gravesend Bay, New York); Linton, Proc. U. S. nat. Mus., *20*, 1897: 451, 452 (cestode parasites, Woods Hole); Smith, Bull. U. S. Fish Comm., *17*, 1898: 90 (listed as common at Woods Hole); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 50 (listed, Florida locals.); Linton, Bull. U. S. Fish Comm., *19*, 1901: 434 (stom. contents, cestode parasites, Woods Hole); Bean, Bull. N.Y. St. Mus., *60*, Zool. *9*, 1903: 59 (descr., habits by ref. to Mitchill 1815, New York); Sharp and Fowler, Proc. Acad. nat. Sci. Philad., *56*, 1904: 506 (listed, Nantucket); Fowler, Rep. N. J. Mus. (1905), 1906: 79 (descr., New Jersey by ref. to Lesueur 1815); Tracy, Rep. R. I. Comm. inl. Fish., 1906: 49 (nos., off Block Island); Fowler, Rep. N. J. Mus. (1906), 1907: 263, pl. 82 (ill., after Lesueur, 1817, New Jersey); Smith, N. C. geol. econ. Surv., *2*, 1907: 47 (descr., season, food, nos., Beaufort, N. Carolina, and size, Florida); Kendall, Occ. Pap. Boston Soc. nat. Hist., *7* (8), 1908: 15 (New England locals., refs.); Fowler, Proc. Acad. nat. Sci. Philad., *61*, 1909: 408 (listed, New Jersey); Gudger, Amer. Nat., *44*, 1910: 397 (nos., size, female with embryos, Beaufort, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *62*, 1910: 475 (listed, New Jersey, N. Carolina); Tracy, Rep. R. I. Comm. inl. Fish., 1910: 64 (nos., off Block Island, weight by ref. to Mitchill, 1815); Gudger, Proc. biol. Soc. Wash., *25*, 1912: 149, 152 (size, embryos, nos. tail spines, Beaufort, N. Carolina); Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 30, 32 (nos., swimming, embryos, uterine wall, C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Gudger, Proc. biol. Soc. Wash., *26*, 1913: 102 (size, testes of mature male, food, Beaufort, N. Carolina); Nichols, Abstr. Linn. Soc. N.Y., 20–23, 1913: 92 (nos., season, near New York); Sumner, Osburn and Cole, Bull. U. S. Bur. Fish., *31* (2), 1913: 739 (nos., food, parasites, Woods Hole); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (nos., C. Lookout, N. Carolina); Fowler, Copeia, 27, 1916: 11 (listed, New Jersey); Copeia, 31, 1916: 41 (listed, New Jersey); Proc. Acad. nat. Sci. Philad., *69*, 1917: 109 (weight, nos., capture, New Jersey); Proc. Acad. nat. Sci. Philad., *71*, 1919: 293 (weight, New Jersey); Proc. biol. Soc. Wash., *33*, 1920: 146 (listed, New Jersey); Townsend and Nichols, Copeia, 91, 1921: 10 (listed near New York); Fowler, Proc. Acad. nat. Sci. Philad., *74*, 1922: 6 (listed, New Jersey); Proc. biol. Soc. Wash., *36*, 1923: 15 (listed, Beaufort, N. Carolina); Copeia, 143, 1925: 43 (listed, New Jersey); Copeia, 156, 1926: 147 (listed, New Jersey); Fish Culturist, *6* (5), 1927: 115 (weight, New Jersey); Nichols and Breder, Zoologica N.Y., *9*, 1927: 28 (south. New England, New York); Fowler, Fish Culturist, *7* (6), 1928: 225 (weights, season, New Jersey); Jordan, Manual Vert. Anim. NE U. S., 1929: 19 (diagn., habits by ref. to Mitchill, 1815); Truitt, Bean and Fowler, Bull. Md. Conserv. Dep., 3, 1929: 33 (descr., Maryland); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 31 (listed, C. Cod to Florida); Fowler, Fish Culturist, *12*, 1933: 264 (listed, Maryland); Breder and Nigrelli, Copeia, 1934: 194 (nos., Sandy Hook Bay); Bere, Amer. Midl. Nat., *17*, 1936: 607 (copepod parasites, season, Lemon Bay, W. Florida); Fowler, Proc. Acad. nat. Sci. Philad., *89*, 1937: 304 (listed, New Jersey); Breder, Bull. N.Y. zool. Soc., *41*, 1938: 49 (listed, New York Harbor); Fowler, Proc. Acad. nat. Sci. Philad., *92*, 1940: 2 (listed, Boca Grande, Florida); Howell-Rivero, Mem. Soc. cubana Hist. nat., *15*, 1941: 259,

pls. 26, 27 (descr., ills., Matanzas, Cuba); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 100, 161 (listed, N. Carolina, S. Carolina).

Probable Reference:

Rhinoptera bonasus Fowler, Rep. N. J. Mus. (1907), 1908: 132 (ident. considered probable, Delaware Bay).

Doubtful references:

Rhinoptera quadriloba Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 279, pl. 47, fig. 4 (descr., photo, teeth, Beaufort, N. Carolina; see discuss., p. 467).

Rhinoptera quadriloba (*bonasus*) Gudger, J. Elisha Mitchell Sci. Soc., *49*, 1933: 76, fig. 11 (abnormal dentition).

Rhinoptera brasiliensis Müller and Henle 1841

Figure 109

Study Material. Three embryos, 205–209 mm wide, with open umbilical scars; five specimens, 430–488 mm wide, either embryos or newborn, but with the umbilical scar still visible and with one or two tail spines; head of one about 910 mm wide as calculated from its breadth between the spiracles; all from Rio Grande do Sul and Rio de Janeiro, Brazil; in Harvard Museum of Comparative Zoology.

Distinctive Characters. *Rhinoptera brasiliensis*, if actually distinct from *R. bonasus*, is separable from the latter only in that it has more series of teeth normally (at least nine in the upper jaw in *R. brasiliensis* but only seven in *R. bonasus*) and that the teeth of the median row average wider transversely relative to their lengths by the time it is half-grown. But the shapes of the teeth, while noticeably divergent in extreme cases (*cf.* Fig. 109 with 108 A), intergrade more or less, and the difference in the number of series of teeth is not sharp cut, for at least two specimens of the genus *Rhinoptera* have been seen with nine series above and only eight below.[52] Hence, an occasional individual with eight rows in both jaws is to be expected, in which case it would not be positively identifiable as either species by the number of teeth. However, it seems wise to recognize the species *brasiliensis*, since comparison of full-grown specimens of the multidentate form (when such are available) with typical *bonasus* may reveal additional differences between the two.

R. brasiliensis agrees with the eastern Atlantic *Rhinoptera marginata* and *R. peli* in the number of series of teeth. However, all but the youngest *R. brasiliensis* appear to be separable from both of these[53] by the fact that teeth in the median series average 5–6 times broader (transversely) than long (anteroposteriorly) in *R. brasiliensis* (only about three times broader than long in *R. marginata* or *R. peli*). Available information also suggests that the anterior contour of the cranium is more deeply concave in *R. brasiliensis* and in *R. marginata* than in *R. peli* (p. 468).

Description. Proportional dimensions in per cent of extreme breadth of disc. Female, 430 mm broad, and male, 488 mm broad, from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 534).

52. One from Brazil in our Study Material; the other from North Carolina, pictured by Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: pl. 47, fig. 4) and by Gudger (J. Elisha Mitchell Sci. Soc., *49*, 1933: 76, fig. 12).

53. If these two are actually separable one from the other; see discussion, p. 468.

Disc: length 56.0, 55.0.
Snout length: in front of orbits 0.9, 0.8; in front of mouth 9.3, 9.4.
Orbits: horizontal diameter 4.6, 4.7; distance between (middle) 10.4, 10.4.
Spiracles: length 3.0, 3.1; distance between 14.9, 15.0.
Mouth: breadth 10.5, 10.9.
Exposed nostrils: distance between inner ends 8.1, 8.4.
Gill openings: lengths, 1st 2.8, 2.7; 3rd 3.0, 3.8; 5th 2.2, 2.0; distance between inner ends, 1st 15.6, 15.6; 5th 10.9, 10.7.
Dorsal fin: vertical height 4.2, 4.5; length of base 6.3, 6.6.
Pelvics: outer margin 9.1, 9.6.
Distance: from tip of snout to center of cloaca 48.4, 50.2; from center of cloaca to origin of caudal spine 11.4, 10.6.

Except for the numbers and shapes of the teeth, the specimens listed as *R. brasiliensis* resemble *R. bonasus* so exactly in general appearance and in proportionate dimensions that to describe them in detail would merely repeat the description of *R. bonasus*. The teeth, as stated previously (pp. 467, 477), are normally in nine series in each jaw. But abnormalities are so frequent that only four out of six free-living specimens seen by us have the normal number; one has eight series in the lower jaw, nine in the upper; one has ten in the upper jaw, nine in the lower; and one jaw (not stated whether upper or lower), apparently referable to *R. brasiliensis*, has been reported as having the normal four series on one side of the median series but eight on the other side, making a total of 13 series.[54] In specimens with the normal number of nine series, the teeth of the median series at birth are about 3.5–4.0 times as broad (transversely) as long (anteroposteriorly); those of the first series outward are about 2–7 times as broad as long; those of the next series on either side are about 1.5 times as broad as long. But in larger specimens the teeth of the median series are 5–7 times as broad as long; those of the first series outward are about 3.5–5.0 times as broad as long, and those of the next series on either side are about 1.7–2.0 times as broad as long. Normally the teeth in the outermost two series are about as broad as long from birth onward. In individuals with more series of teeth than normal, those in the series next to the median are likely to be wider than normal; but those of the second series outward from the median series are narrower than normal in specimens with fewer than nine series, the outermost series being very small. These variations meet the spacial requirements of an increase or decrease in the number of series with the relative breadth of the mouth remaining the same. The final number of series of teeth, as well as the pavement-like arrangement of those of the more posterior rows, is established in embryos not more than about 200 mm wide. But the teeth of the two or three anterior embryonic rows are minute, rounded, loosely spaced, and lost before birth. Such is the case in *R. bonasus* also.

54. According to Woodward (Ann. Mag. nat. Hist., [6] *1*, 1888: 282), who pictured this specimen and discussed its dentition at some length, it was "evidently referable to the Brazilian species *R. jussieui*." But its geographic origin was not definitely stated. See also Gudger (J. Elisha Mitchell Sci. Soc., *49*, 1933: 82, fig. 16).

Color. Specimens preserved in alcohol are brown above, brownish white below, darker towards the tips of the pectorals.

Size and Development. The state of development of specimens 435–488 mm wide in our Study Material (p. 477) suggests a breadth of about 450–500 mm at birth, which is approximately the same as for *R. bonasus*. The largest specimens reported have been 890 (one)[55] and about 910 mm (one) wide.[56] But no information is available as to the size at sexual maturity or as to the maximum to which *R. brasiliensis* may grow.

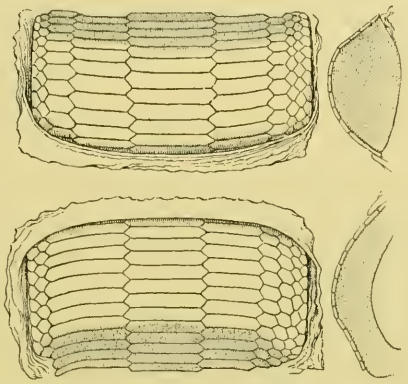

FIGURE 109. *Rhinoptera brasiliensis*, upper teeth (above) with front row uppermost, and lower teeth (below) with front row lowermost, from head of a specimen about 910 mm wide (estimated), from Rio de Janeiro, Brazil (Harv. Mus. Comp. Zool., No. 534), about 0.4×.

Habits. Nothing whatever is known of the habits of this Ray.

Range. In the western Atlantic, all reported captures of Cow-nosed Rays with nine or more series of teeth in one jaw or in both, hence referable to *R. brasiliensis*, have been from Santos, Rio Grande do Sul, and Rio de Janeiro, Brazil, except for a single specimen from Beaufort, North Carolina, which had nine series above and eight below. With no more than this to go on, it seems likely that this last specimen was actually an aberrant *R. bonasus* and that the range of the multidentate species *R. brasiliensis* is normally restricted to the South American Coast in the southern hemisphere.

Synonyms and References:

Rhinoptera brasiliensis Müller, Vergl. Anat. Myxinoiden, 1835: 276, pl. 9, fig. 12 (ill. skel. of head); Müller and Henle, Plagiost., 1841: 182 (descr., meas., Brazil); Duméril, Hist. Nat. Poiss., *1*, 1865: 646 (descr., size, Brazil).

Rhinoptera jussieui Günther, Cat. Fish. Brit. Mus., *8*, 1870: 493 (descr., Brazil specimen); Woodward, Ann.

55. Duméril, Hist. Nat. Poiss., *1*, 1865: 646.

56. Breadth as calculated from breadth between spiracles of detached head; see Study Material, p. 477.

Mag. nat. Hist., (6) *1*, 1882: 282 (abnormal dentition, see p. 467); Bateson, Materials for Study of Variation, 1894: 259, 260, fig. 69 (same jaw as in Woodward 1882); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 82 (listed, Rio de Janeiro); Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 193, 211, pl. 20 (descr., refs., photo, Brazil); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 447, pl. 48, figs. 1–3, pl. 54, fig. 5, pl. 55, fig. 10, pl. 57, fig. 5, pl. 59, figs. 9, 10, pl. 74, figs. 1–3 (descr., ills., teeth, pelvis, vertebrae, heart, gills, skel.); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Santos, Brazil); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 48 (same as in Ribeiro 1907); Gudger, J. Elisha Mitchell Sci. Soc., *49*, 1933: 82 (abnormal dentition); White, Bull. Amer. Mus. nat. Hist., *74*, 1937: 91 (no. heart valves, after Garman 1913).

Not *Myliobatis jussieui* Cuvier, Règne Anim., *2*, 1829: 401, footnote 3 (name by ref. to ill. by Jussieu [Mém. Acad. Sci. Paris (1721), 1723: 75, pl. 4, fig. 12], jaw with seven rows of teeth, from China).

Not *Zygobatis jussieui* Agassiz, Poiss. Foss., *3*, 1835: pl. D, fig. 8; *3*, 1838: 79, 328 (teeth, ill. after Jussieu 1723, of jaw from China).

Not *Zygobates jussieui* Agassiz, Poiss. Foss., *3*, 1843: 328 (same as *Zygobatis jussieui* Agassiz 1838).

Family MOBULIDAE[57]

Devil Rays, Devil Fishes[58]

Characters. Myliobatoidea with disc thinner vertically than that in Myliobatidae, tapering forward to wedge-like anterior margin, thus streamlined for easy swimming when mouth is closed. Tail much longer than body, tapering to lash-like tip, with or without serrate-edged spine (or spines). Head noticeably broad, its dorsal surface flat or only slightly convex transversely. Outer anterior margins of pectorals entirely interrupted on sides of head just posterior to eyes, the anterior division of each pectoral forming a separate narrow ear-like lobe, the so-called cephalic fin, curving forward from front of head, its transverse axis nearly vertical; the two cephalic fins widely separated one from the other; their basal attachments to head extending from below spiracle upward and forward to upper anterior extension of cranium; supported by numerous slender and flexible radial cartilages closely crowded in single series. Dorsal fin on base of tail. No caudal fin. Orbits not prominent. External openings of spiracles much smaller than eyes, directed rearward, firm-edged and apparently not at all expansible, but preceded anteriorly by a well marked groove along side of head. Nostrils entirely separate from mouth. Mouth either terminal or on lower surface of head; nearly straight, and very broad, as is space between nostrils; a transverse curtain on roof of mouth, smooth-edged or with finely fringed margin; no papillae either on roof or on floor of mouth. Gill openings much longer than eye, and much longer than in the Eagle, Duck-billed, or Cow-nosed Rays (Myliobatidae, Rhinopteridae, cf. Fig. 113B with 105F). Teeth in both jaws or in only one, minute, in many series, forming a band.

Skin, apart from tail spines, either naked or more or less rough with small tubercles or prickles. Other external characters as in suborder Myliobatoidea.

Front of cranium moderately concave in broadly arcuate contour, a rounded prom-

57. Classed by Whitley (Aust. Zool., *8* [3], 1936: 165) as a superfamily, Mobuloidea.

58. The basis for these common names was the fancied resemblance of the forward-pointing cephalic fins to the horns in medieval representations of the devil.

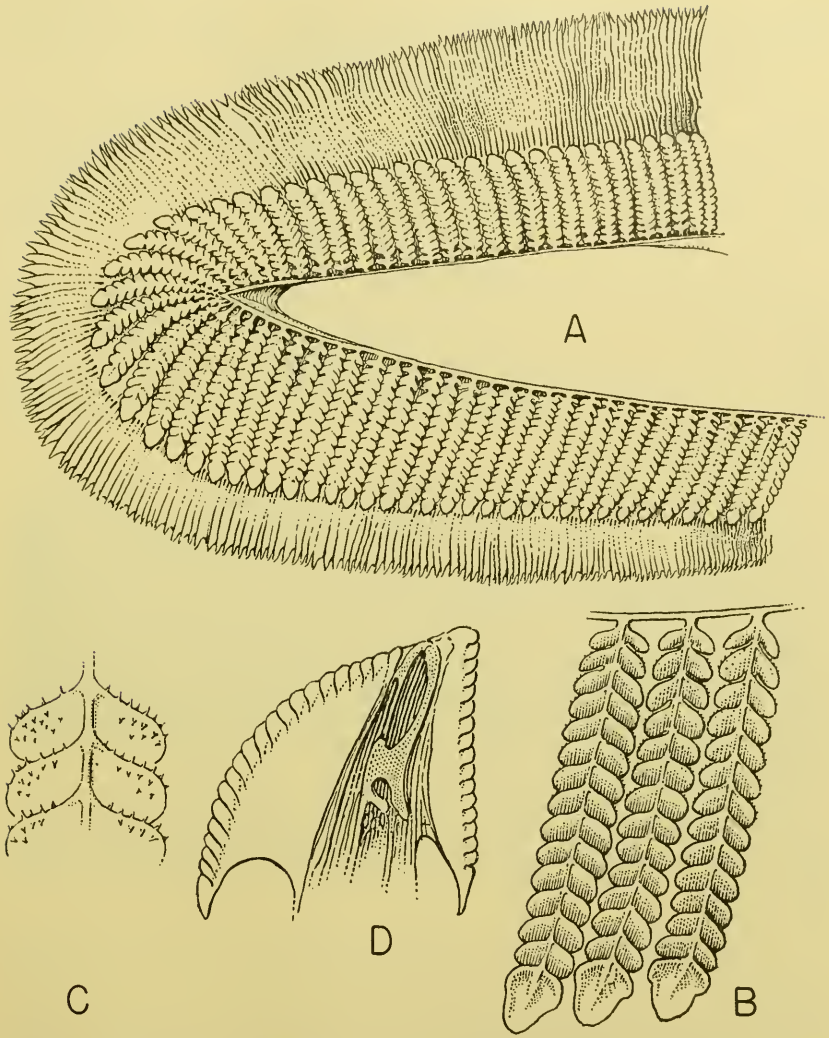

FIGURE 110. *Mobula hypostoma*, female, 845 mm wide, from Brazil. *A* Anterior side of second right-hand branchial arch to show general arrangement of gill plates and gill folds, about 1.7×. *B* Margins of three gill plates, to larger scale, showing arrangement of lateral lobes, about 5.2×. *C* Lobes from same, about 13×. *D* Cross section of inner part of lower limb of arch about midway of its length to show shapes of plates on posterior face (left-hand) as compared with those on anterior face (right-hand), about 2.5×.

inence on either side providing support for anterior radial cartilages of cephalic fin. Cephalic fin with 24–26 slender radial cartilages. Pelvis strongly arched with long slender median process directed forward (Fig. 79 E).[59]

Remarks. The most interesting anatomical feature peculiar to the mobulids is that each of the inner branchial openings through which the pharynx connects with the gill pouches is entirely surrounded, and thus guarded, by a single series of lamellae or gill plates[60] implanted on the visceral arches at right angles to the latter: one series on the posterior face of the hyoid arch; a series on each face of the first to fourth branchial arches; and a series on the anterior face of the fifth arch. Their arrangement thus parallels that of the gill filaments.

These gill plates are thin, are either membranous or more or less horny, and have cartilaginous basal supports. They are several times as long as high, the free margin rising from the inner face of the gill arch toward the outer face, i. e., toward the gill folds (Figs. 110D, 112A), with the plates on the posterior face of each arch more or less semilunar in lateral outline. There may be as many as 85–100 gill plates per arch in *Mobula*, 130–140 in *Manta* at a breadth of 15 feet; undoubtedly there is a still larger number in the adult Mantas.

The free distal edge of each plate is expanded transversely in double-pinnate form. In the genus *Mobula* the outer extremities of these lateral expansions of adjacent plates are in the form of rounded lobes which continue separate one from another though closely in contact (Fig. 110). But in *Manta* (Figs. 111, 112) they are rod-like, and those of adjacent plates are fused at their tips in more or less zigzag pattern. Thus in *Manta* they form a continuous grid or sieve on each of the faces (anterior and posterior) of each of the gill-bearing arches,[61] extending across the whole breadth of the zone occupied by the plates and around the entire length of each gill arch. With upwards of 130–140 plates on either gill-bearing face of each arch, and with each plate connected with the neighboring plate on either hand by some 40–70 bars or more, the total number of openings per arch in each of its branchial sieves is something like 7,000–9,000 on two-thirds grown specimens, doubtless many more on adults.[62]

Each opening in the branchial sieve is partially subdivided by some 13–16 (or more) round-tipped lobelets along the face toward the pharynx of each of the bars. And the presence of many sharp conical denticles scattered irregularly over these lobelets and over the inward- and outward-facing surfaces of the gill bars renders the sieve still finer.

Since the individual plates increase in height outward across each arch toward the

59. For account of modifications of the branchial rays, see Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: pl. 75 and expl.).

60. Also termed prebranchial plates or prebranchial appendages.

61. The structure of the branchial sieve has long been known for *Mobula* (p. 484, footnote 63), but to our knowledge it has not been described previously for *Manta*.

62. On our 11 foot 5 inch specimen of *Manta* there are 136 plates on the anterior face and 132 on the posterior face of the first branchial arch. Each plate is connected with its neighbors on the anterior face by 43–46 crossbars along the dorsal half of the arch and by 60–63 crossbars along the ventral half; by about 55–60 crossbars along the dorsal half and by about 75 bars along the ventral half on the posterior face of the arch.

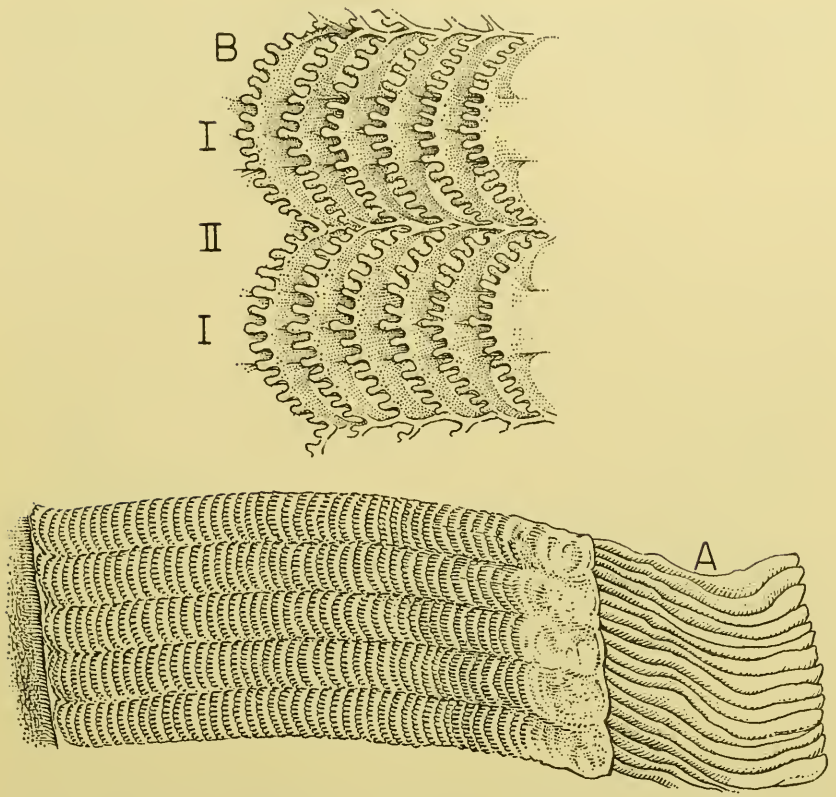

FIGURE 111. *Manta birostris*, juvenile male, 11 feet 5 inches wide, from Bimini, Bahamas. *A* Anterior view of part of branchial sieve, with gill folds (outer end toward right), from anterior side of first branchial arch, to show general appearance, about 1.8×. *B* Portion of same, showing (I) locations of gill plates and (II) line of junction between transverse bars born by adjacent gill plates, about 6.5×.

zone occupied by the gill filaments, any contraction of the pharynx (as in breathing) tends to bring the pinnate distal edges of the plates on each arch into contact with the plates on the two adjoining arches along the outer sides of the latter, the plates along the inner parts of successive arches continuing far apart (Figs. 110, 112A). Consequently, the only route by which the water that is expelled from the pharynx can reach the external gill openings is via the meshes of the grid or sieve to the channels that lead outward between the basal parts of adjacent gill plates. In this way, any small animals that are taken in with the water through the mouth are retained within the

pharynx on the inner surface of the branchial sieve, whence they are swallowed.[63] Thus the gill plates, corresponding in position and arrangement to the much simpler and lower transverse ridges borne on the arches of the Rhinopteridae (p. 465), serve the same purpose as the horny gill rakers of the Basking Shark (*Cetorhinus*) and the gill sieve of modified dermal denticles of the Whale Shark (*Rhincodon*). It may not be out

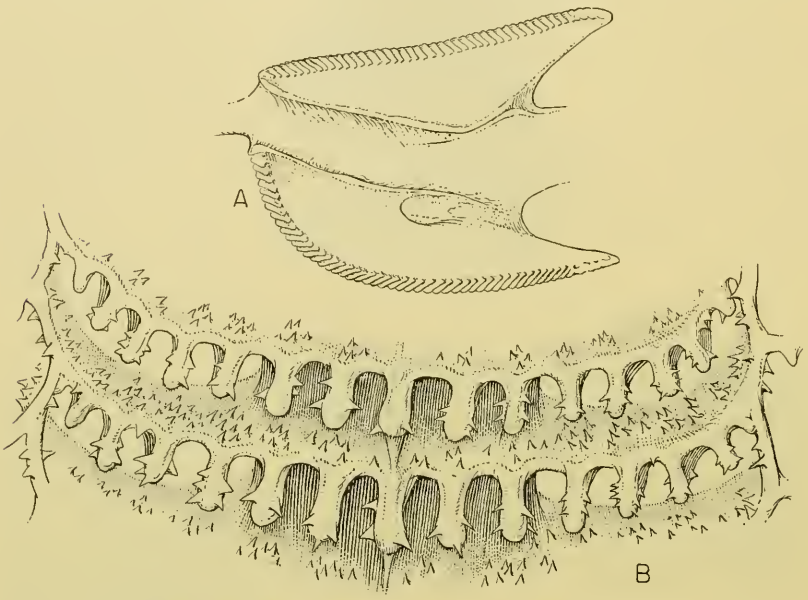

FIGURE 112. *Manta birostris*, same specimen as in Fig. 111. *A* Lateral views of gill plates (outer ends toward right) from anterior side of arch (above) and from posterior side of arch (below), to show difference in shape, about 1.2×. *B* Branchial sieve, magnified to show openings and lobelets with denticles, about 28×.

of place for us, like so many before us, to call attention to the fact that it is the largest Sharks and Rays and the largest mammals (Whalebone Whales) that strain their food out of the water, while the bony fishes that do so are among the smaller members of the group.

It is probable,[64] both from the smallness of their spiracles and from their method of feeding, that the mobulids take in the water for respiration chiefly through their mouths rather than through their spiracles, as all other batoids appear to do (p. 7).

63. For additional accounts and illustrations of the gill plates of *Mobula*, see especially: Panceri and de Sanctis (Sopra. . . *Cephaloptera giorna*, Naples, 1869: 6, pl. 1, figs. 1, 2; Atti Accad. Pontan. Napoli, 9, 1869: 341, pl. 1, figs. 1, 2); Duméril (Ann. Mag. nat. Hist., [4] 5, 1870: 385, 386); Bertolini (Boll. Soc. Biol. sper., 9, 1934: 1270, fig. 1, photo); for gill plates of *Manta*, not previously described, see p. 482.

64. No actual observations appear to have been made on the method of respiration of the mobulids.

Size. This family includes the largest of the batoids, some of them (genus *Manta*) growing to a width of more than 20 feet and to a weight of more than 3,000 pounds.

Development. The Devil Rays are ovoviviparous. The uterine wall of the gravid female is covered with the vascular villi[65] which are characteristic of ovoviviparous Rays in general and which discharge a milk-like fluid on which the embryos are nourished during the later stages in their growth.

Habits. To a large extent the Devil Rays appear to have abandoned life on the bottom to swim mostly near or at the surface. Like the myliobatid Rays, they progress through the water by a flapping motion of the wing-like pectorals which suggest flying rather than swimming. They often leap above the surface or somersault in the air, falling back in the water with a loud splash; sometimes companies of them do so together or in rapid succession. However, the feature that chiefly distinguishes the habits of the mobulids from those of other myliobatoid Rays is that they subsist on small pelagic organisms, chiefly smaller schooling fishes and planktonic crustacea. These they gulp into their capacious mouths, apparently employing the flexible cephalic fins "to assist in scooping the food into the mouth,"[66] as described in more detail on p. 493. Old tales that they use these fins to grasp swimmers or objects such as the anchor lines of boats appear to have a foundation in fact (p. 509).

Range. Tropical to warm-temperate belts of all oceans, including the Mediterranean, both in continental waters and around offlying island groups.

Genera. By common consent, primary subdivision of the family is based on the position of the mouth, across the front of the head (terminal) or on the lower surface. On this basis the group has been subdivided recently into two families[67] or subfamilies.[68] We follow the older and more usual course of regarding this distinction as a basis for generic rather than family grouping. A secondary generic character is whether there are teeth in both jaws or in one only, upper or lower. On the basis of these criteria, two long-known genera are generally recognized: *Manta* with a terminal mouth and with teeth in the lower jaw only; *Mobula* with the mouth on the lower side and with teeth in both jaws. A third genus, *Ceratobatis* Boulenger 1897, has been based on a single specimen with the mouth on the lower surface as in *Mobula* but with teeth in the upper jaw only (p. 500). The genus is accepted here provisionally, but the possibility must be recognized that the specimen in question may have been an abnormal *Mobula*. A fourth genus of large Devil Rays with teeth in both jaws has recently been named *Indomanta* Whitley 1936.[69] Apparently its mouth is terminal, as is the case in *Manta*, but the original illustration[70] of the specimen on which it was based leaves this point in doubt. If its mouth were on the lower surface it would appear to have been a large *Mobula*.

65. See Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: 280) for an account of the uterine wall.
66. Norman and Fraser, Giant Fishes, 1937: 83.
67. Ceratopteridae, with mouth terminal, and Mobulidae, with mouth inferior, by Whitley (Aust. Zool., *8* [3], 1936: 165), who regards the mobulids as a superfamily rather than as a family.
68. Mantinae, with mouth terminal, and Mobulinae, with mouth inferior, by Fowler (Proc. Acad. nat. Sci. Philad., *85*, 1934: 243; Bull. U. S. nat. Mus., 100 [*13*], 1941: 479).
69. Aust. Zool., *8* (3), 1936: 183.
70. Tombazi, J. Bombay nat. Hist. Soc., *37*, 1934: 227, *Dicerobatis eregoodoo* Tombazi; apparently not *D. eregoodoo* Cantor (J. Asiat. Soc. Beng., *18*, 1849: 1420), which equals *Mobula diabola* Shaw 1804.

Key to Genera

1a. Mouth on lower surface of head.
  2a. Teeth in both jaws. *Mobula* Rafinesque 1810, p. 486.
  2b. Teeth in upper jaw only. *Ceratobatis* Boulenger 1897, p. 497.
1b. Mouth terminal, extending across front of head.
  3a. Teeth in lower jaw only. *Manta* Bancroft 1828–1829, p. 500.
  3b. Teeth in both jaws. *Indomanta*[71] Whitley 1936. India.

Genus *Mobula* Rafinesque 1810

Mobula Rafinesque, Indice Ittiol. Sicil., 1810: 48, 61; type and only included species, *M. auriculata* Rafinesque, equals *Raja mobular* Bonnaterre 1788.

Generic Synonyms:

Apterurus Rafinesque, Indice Ittiol. Sicil., 1810: 46, 62; type and only included species, *A. fabroni* Rafinesque, emended spelling for *Raja fabroniana* Lacépède 1799–1800,[72] equals *Raja mobular* Bonnaterre 1788.

Cephalopterus[73] Risso, Ichthyol. Nice, 1810: 14; type species, *Raja giorna* Lacépède 1802–1803,[74] equals *Raja mobular* Bonnaterre 1788.

Apturus Rafinesque, An. Nature, 1815: 93; emended spelling for *Apterurus* Rafinesque 1810.

Dicerobatus Blainville, Bull. Soc. philom. Paris, 1816: 112; type species, *Raja mobular* Bonnaterre 1788, designated by Jordan (Genera Fish., 1, 1917: 95).

Cephaloptera Cuvier, Règne Anim., *2*, 1817: 138; type species, *Raja cephaloptera* Bloch and Schneider 1801.

Dicerobatis Blainville, in Vieillot, Faune Franç., 1825: 40; type and only included species, *D. mobular* Blainville, equals *Raja mobular* Bonnaterre 1788.

Cephalopteram Griffith and Smith, in Cuvier, Règne Anim., *10*, 1834: 617, footnote 2; erroneous spelling for *Cephaloptera* Cuvier 1817.

Ptcrocephalus Swainson, Nat. Hist. Fish. Amphib. Rept., *1*, 1838: 170, 174; type species, *Pt. massena* Swainson, Mediterranean, equals *Raja mobular* Bonnaterre 1788.

Pterocephala Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1839: 321; type species, *Raja giorna* Lacépède 1802–1803, equals *Raja mobular* Bonnaterre 1788.

Diarobatus Agassiz, Nom. Zool. Index, Pisces, 1845: 22; emended spelling for *Dicerobatus* Blainville 1816.

Aodon Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 91; type and only described species, *Cephalopterus hypostomus* Bancroft 1831; doubtful whether *Aodon* Rafinesque 1810.

Doubtful Synonym:

Aodon Rafinesque, Indice Ittiol. Sicil., 1810: 46; Sicily; type and only included species, *A. comutus* Rafinesque, probably equals L'Aodon cornue, Lacépède (Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 297, 300); French name for *Squalus edentulus* Brünnich 1768 (Ichthyol. Massil., 1768: 6), based on dried head of a mobulid of doubtful identity, described as having cephalic fins but lower jaw without teeth; in Pisa Museum; no definite locality.

Not *Aodon* Bosc, Nouv. Dict. Hist. Nat., *1*, 1803: 511; Duméril, Zool. Analyt., 1806: 103; type species, *Squalus messasa* Bonnaterre 1788 (Tabl. Encyc. Meth. Ichthyol., 1788: 13), designated by Jordan and Evermann (Rep. U. S. Comm. Fish. [1895], 1896: 225); equals (misprint) *Squalus massasa* Forskål 1775 (Descr. Anim. X); problematical elasmobranch from the Red Sea, described as having long pectoral fins but no teeth.[75]

71. Its status is problematical; see preceding discussion.
72. Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *2*, [An. VIII] 1799–1800: 111, pl. 5, fig. 1.
73. But preoccupied by *Cephalopterus* Geoffrey St.-Hilaire 1809, for birds.
74. Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *5*, [An. XI] 1802–1803: 666, pl. 20, fig. 3.
75. For further discussion of the history of *Aodon*, used also as the vernacular name for certain small Toothed Whales by Lesson (Compléments de Buffon, *1*, 1828: 592), see Whitley (Aust. Zool., *8* [3], 1936: 165).

Not *Anodon* Agassiz, Nom. Zool. Index, 1846: 24; emended spelling for l'Aodon massasa, Lacépède 1798 (Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 298); equals *Squalus massasa* Forskål 1775; see above.[76]

Generic Characters. Mobulidae with mouth on lower surface and with teeth in both jaws. Front of head wedge-shaped dorsoventrally, the anterior edge sharp. Cephalic fins thin, leaf-like, directed obliquely forward and downward, very flexible; curved from below outward in a subcylindrical roll when swimming, but unrolled and capable of curvature inward when capturing planktonic prey (see p. 493). Dorsal fin at base of tail opposite bases of pelvics. Pelvic fins extending but little beyond posterior corners of pectorals. Mouth only a little posterior to front of head; articulation of jaw cartilages so loose and skin so distensible that lower jaw, when opened, drops equally low across width of mouth from corner to corner; gape subrectangular, about $^1/_4$ to $^1/_3$ as deep vertically as wide transversely and facing directly forward. Skin more or less roughened with small spines. Lateral pinnations of free distal margins of adjacent branchial plates separate, not fused as in *Manta* (pp. 482, 501). Characters otherwise those of the family.

Size. One species, *Mobula mobular* of the eastern Atlantic, rivals and possibly equals the breadth of the Giant Devil Ray (*Manta*).[77] At the other extreme, *Mobula diabola* in Australian waters "grows to only a couple of feet wide."[78] *Mobula hypostoma* of the western Atlantic matures at a width of about 3 $^1/_4$ feet, and we found no definite record of a measured specimen wider than four feet (p. 493, footnote 99).

Diet. The stomach contents of Devil Rays of this genus examined thus far have consisted of small fishes or of either euphausiid- or mysid-like crustaceans, of which large ones may contain several quarts.[79]

Range. Both sides of the Atlantic; Island of St. Helena[80] northward to the Mediterranean, Portugal, and accidentally to southern Ireland in the east;[81] Brazil to Cape Lookout, North Carolina, and as a stray to the vicinity of New York in the west; Lower California (perhaps Gulf of California and Costa Rica) and northern Chile[82] on the west coast of America; Hawaiian Islands; western Pacific from Japan to southern Queensland; East Indian-Philippine-Malayan region in general; coasts of the Indian Ocean from Bay of Bengal and Gulf of Oman to Madagascar, Natal, and the southeast coast of Africa;[83] also the Red Sea.

Species. The members of the genus fall in two divisions: (a) with a tail spine (or

76. The generic name *Anodon* had already been used by Oken (Lehrb. Naturg., *3*, Zool., *1*, 1815: 236) for mollusks; by Smith (Zool. J., *4*, 1829: 443) for reptiles; and by Wagler (Syst. Amphib., 1830: 34; not seen) for cetacea.
77. See p. 496 for records of large specimens of *M. mobular*. 78. Whitley, Fish. Aust., *1*, 1940: 226.
79. Bertolini, Boll. Soc. Biol. sper., *9*, 1934: 1270; McGinitie, Copeia, 1947: 277.
80. The Devil Ray from St. Helena, pictured in ventral view by Russell (Fish. Coromandel, *1*, 1803: pl. 9 bis), was either a *Mobula* or a *Ceratobatis*, as shown by the position of its mouth.
81. The capture of a *Mobula* off the south coast of Ireland about 1830 was reported nearly simultaneously by Thompson (Proc. zool. Soc. Lond., 1835: 78) by Yarrell (Brit. Fish., *2*, 1836: 446), and later by M'Coy (Ann. Mag. nat. Hist., *19*, 1847: 176, pl. 11).
82. The Devil Ray reported from Chile as *Cephaloptera ? tarucapana* by Philippi (An. Mus. nac. Chile, Sec. 1, Zool. 3, 1892: 8, pl. 3, fig. 2) appears to have been a *Mobula*, since the drawing shows its mouth on the lower surface.
83. *Mobula diabola* has been reported recently from Port Alfred, S. Africa (Smith, Trans. roy. Soc. S. Afr., *30*, 1943: 75; Sea Fish. S. Afr., 1949: 72).

spines) and (b) without. In the Atlantic each of these groups is represented by a single well defined species, namely *M. mobular* (Bonnaterre) 1788[84] with tail spine and *M. hypostoma* (Bancroft) 1831 without. A *Mobula*, whose specific identity cannot be determined because information is lacking as to the presence or absence of a tail spine, has been pictured from the Island of St. Helena in the South Atlantic.[85] The half dozen species that have been named from the western Pacific-Indian Ocean region and from the Hawaiian Islands appear similarly to be reducible to two: *M. japanica* (Müller and Henle) 1841 with tail spine and *M. diabola* (Shaw) 1804[86] without.

One representative of the genus, *Mobula lucasana* Beebe and Tee-Van 1938,[87] which lacks a tail spine, has been described from the eastern side of the Pacific (Lower California, probably the Gulf of California and Costa Rica as well). A spineless *Mobula*, *M. tarapacana* Philippi 1892, has been reported also from Chile, but its relationship to *M. lucasana* is problematical, for the old drawing on which the name was based was evidently faulty.

Key to North Atlantic Species

1 a. Tail with a spine (or spines).	*mobular* (Bonnaterre) 1788, p. 495.
1 b. Tail without a spine.	*hypostoma* (Bancroft) 1831, p. 488.

Mobula hypostoma (Bancroft) 1831

Lesser Devil Ray

Figures 110, 113, 114

Study Material. Four females, 550–1,070 mm wide, from: Brazil; New Smyrna Beach, East Florida; and Cape Lookout, North Carolina;[88] in Harvard Museum of Comparative Zoology.

Distinctive Characters. The presence of cephalic fins gives to these Devil Rays so characteristic an appearance that they could not be mistaken for any other batoid except some other member of their own family. In the present case there is little danger of this, for its smaller size and the position of its mouth on the under side mark it off at a glance from the Giant Devil Ray, *Manta birostris;* the presence of teeth in its lower jaw, easily felt if not seen, separates it from *Ceratobatis;* and its lack of a tail spine dis-

84. Whitley (Aust. Zool., *8* [3], 1936: 185) uses the specific name *edentula* (Brünnich) 1768 for this species rather than *mobular* (Bonnaterre) 1788. However, the dried head on which *edentula* was based seems more likely to have been a *Ceratobatis* than a *Mobula*, for it was described as lacking teeth in the lower jaw and as having the upper dental plate rough like the surface of a file ("Surficies limae instar scabra", Brünnich, Ichthyol. Massil., 1768: 6). Nothing is known of its geographic origin, other than that it was in the Pisa Museum.

85. Russell, Fish. Coromandel, *1*, 1803: pl. 9 bis, ventral view.

86. See Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 480) for synonyms and references for these. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 450) classed *M. diabola* (Shaw) 1804 as a synonym of *M. mobular* of the eastern Atlantic and Mediterranean, but Shaw definitely based his *M. diabola* on the Eereegoodee Tankee of Russell (Fish. Coromandel, 1803: 5, pl. 9) from India.

87. Zoologica N. Y., *23*, 1938: 299, pls. 1–3.

88. One catalogued as from Danville, Virginia (a locality far inland) probably was from Cape Lookout because it was from the collection of the late R. J. Coles, whose extensive observations on elasmobranchs were made in that vicinity.

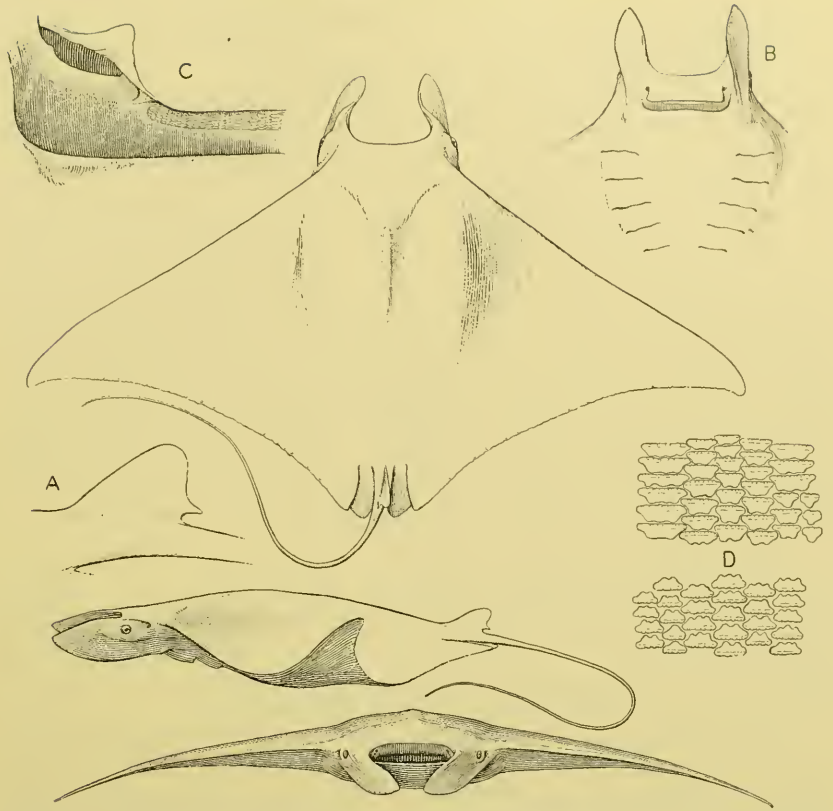

FIGURE 113. *Mobula hypostoma*, female, 836 mm wide, from Brazil (Harv. Mus. Comp. Zool., No. 683). *A* Side view of dorsal fin, about 0.5×. *B* Lower surface of head and gill region to show cephalic fins, nasal curtain, and mouth. *C* Right-hand corner of mouth with nasal curtain rolled forward to show nostril and outer part of tooth band, about 0.9×. *D* Upper teeth (above) with front row uppermost, and lower teeth (below) with front row lowermost, about 4.6×.

tinguishes it from its genus mate *Mobula mobular;* these are the only other Devil Rays known from the North Atlantic.

Description. Proportional dimensions in per cent of width of disc. Female, 836 mm wide, from Brazil (Harv. Mus. Comp. Zool., No. 683); female, 1,070 mm wide, from North Carolina (Harv. Mus. Comp. Zool., No. 1378).

Disc: length from snout 50.3, 57.6.

Snout length: in front of mouth 3.3, 3.8.

Orbits: horizontal diameter 2.8, 2.4; distance between 16.5, 18.1.

Spiracles: length 1.4, 1.7; distance between 17.5, 18.9.
Mouth: breadth 12.8, 13.6.
Exposed nostrils: distance between inner ends 10.5, 11.9.
Gill openings: (average of both sides) length, 1st 5.7, 6.0; 3rd 5.9, 6.7; 5th 4.1, 4.4; distance between inner ends, 1st 13.7, 15.1; 5th 3.7, 4.5.
Dorsal fin: vertical height 4.0, 4.6; length of base 5.1, 6.3.
Pelvics: anterior (outer) margin 6.7, 6.5.
Distance: from center of snout to center of cloaca 40.2, 44.3; from center of cloaca to tip of tail 68.2, 71.0.

Disc, exclusive of cephalic fins, about twice as broad as long, with well marked mid-dorsal crest from nuchal region to pectoral girdle; its thickness at pectoral girdle (where thickest) about 14 % as great as breadth of disc from tip to tip. Tail (if intact) from center of cloaca at least 1.5 times as long as body from center of cloaca to front of head;[89] moderately stout below dorsal fin, tapering gradually rearward to lash-like tip and strongly compressed laterally throughout its length; its anterior part, opposite posterior end of dorsal, about 1.5 times as high as wide; its sides rounded below dorsal fin but nearly flat rearward from latter; upper surface of tail with a faintly indicated median ridge for a short distance posterior to dorsal fin; skin not reticulate.[90]

No tail spine.

Skin of small specimens naked except for a few soft minute spines on trifid bases scattered along mid-dorsal belt of posterior part of disc; larger specimens with fine prickles, either sparse or close-set, along median belt from head to dorsal fin; also here and there on pectorals; discs of some mature specimens perhaps more generally prickly; upper surface of tail naked posterior to dorsal fin; lower surface of tail smooth, but abdominal region more of less roughened with minute prickles.

Head nearly flat above or weakly convex transversely, without longitudinal depression; its thickness at level of mouth a little more than 1/3 as great as breadth between eyes; its dorsal profile sloping a little forward to sharp front margin; its anterior contour weakly and evenly concave. Eyes on sides of head at about midlevel, nearly circular, their diameter a little more than half as great as distance from mouth to front of head, or about 13 % as great as width of head between orbits. Spiracle circular, with firm rim, a little less than half as large as eye; about level with eye and posterior to posterior margin of latter by a distance a little greater than diameter of eye; spiracular opening preceded by a groove extending to above eye.

Gill openings straight or slightly wavy in outline, their lengths on each side not always equal; first to fourth gill openings a little more than half as long as distance between inner ends of exposed nostrils; fifth about 70–75 % as long as first; distance between inner ends of first gills about 1.2 times as great as distance between inner

89. Museum specimens are likely to have lost part of their tails.
90. The skin close behind the dorsal fin is described as reticulate in *Mobula lucasana* of the Pacific Coast of Central America (Beebe and Tee-Van, Zoologica N. Y., *23*, 1938: 300).

ends of nostrils; distance between inner ends of fifth gills about 30 % as great as distance between first gills.

Nasal openings strongly oblique, all but their outer ends roofed over by nasal curtain; distance between outer ends of nostrils 60–65 % as great as breadth of head at level of mouth; outer posterior margin of nostril with a broad subtriangular lobe extending inward over nasal aperture, visible if nasal curtain is rolled back; nasal curtain short, its outer corner about a right angle, slightly blunted, its free posterior margin nearly straight, smooth-edged, and free from upper lip throughout its length; its internal surface, near outer end, with a transverse fold, the free edge directed toward center of mouth. Mouth occupying about $^2/_3$ of breadth of head; lower jaw bowed

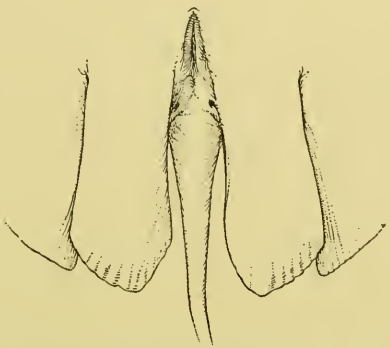

FIGURE 114. *Mobula hypostoma*. Ventral view of pelvic fins of female pictured in Fig. 113, about 0.6×.

slightly forward; distance from upper jaw to front of head about $^1/_3$ as great as breadth of mouth and about 90 % as great as distance between inner ends of fifth gill openings. Tooth bands narrow, fusiform, flexible, only loosely attached to the jaws; occupying median 45–47 % of upper jaw and slightly less of lower jaw in specimens seen; perhaps relatively longer in largest individuals.

Teeth $\frac{36}{38}$ in female 836 mm wide, $\frac{72}{58}$ in female 1,070 mm wide[91]; teeth of females ovate, diamond-shaped, squarish or rectangular, of different sizes (all variations sometimes present on same individual), without cusp; anterior margins straight or somewhat arched or roughly triangular, but with indistinct scalloping; posterior margins with 1–3 low subtriangular rounded prominences; teeth of males more closely crowded, usually with two but often with one or three (occasionally four or five in lower jaw) long,

91. $\frac{57}{47}$ on male and $\frac{53}{48}$ on female, reported by Radcliffe (Bull. U. S. Bur. Fish., *34*, 1916: 279). The original account of the species credited it with 80 series of teeth. But Duméril (Hist. Nat. Poiss., 1865: 657) has pointed out that this larger number no doubt resulted from inclusion of more than one row of teeth in the count.

slender, blunt-tipped cusps directed inward into the mouth; those of each row overlapping the row next behind; about ten rows of teeth in function simultaneously in each jaw in both sexes. Series of abnormally wide teeth are rather common in both sexes.[92]

Cephalic fins about twice as broad (basally) as long, tapering to blunt tips, their shape as shown in Fig. 113; their anterior margins level with median sector of anterior margin of head, their dorsoventral axes sloping a little outward from above to below, their bases terminating about under spiracles at level of lower surface of head; their lower margins rolled outward-upward when swimming but flattened when feeding (p. 493), the anterior parts capable of curving inward toward mouth. Main portions of pectorals originating close posterior to spiracles and on a level with latter, or a little higher; anterior margins of pectorals nearly straight from points of origin but increasingly convex toward outer corners; posterior margins moderately and evenly concave; outer corners subangular; rear corners narrowly rounded or subangular; inner margins moderately convex, about half as long as distance between eyes. Dorsal fin with moderately convex anterior margin and broadly rounded apex; posterior margin indented basally, as illustrated in Fig. 113A; its origin about opposite axils of pectorals; its free rear corner about even with rear corners of pelvics; its base about $^1/_3$ as long as distance between eyes; its vertical height about 72–80 % as great as length of its base. Pelvics noticeably small, extending only a little beyond posterior corners of pectorals; anterior margin nearly straight; posterior contour obtusely wedge-shaped, with blunted corner; length along anterior (outer) margin about 64–70 % as great as distance from origin of pelvic to rear corner. Claspers of mature male extending beyond posterior corners of pelvic fins for a distance about as great as extreme length of dorsal; cylindrical, with a keel-shaped projection capable of erection near the tip.[93]

Cranium produced anteriorly at either side as a rounded prominence, supporting anterior cartilages of cephalic fins.

Color. Upper surface of disc and pelvics, dorsal fin, and both upper surface and sides of tail blackish brown in western Atlantic specimens (after preservation), the dark shade extending down sides of head to surround eyes and forming a conspicuous blotch onto lower surface on each side close posterior to them; upper margins and inner terminal portions of cephalic fins of same dark color as back. Outer surfaces of cephalic fins and lower surface of disc and tail pale yellowish or grayish white except for the dark ocular blotch mentioned above; tips of pelvics more or less dusky. Living specimens are described as black above, changing soon after death to dark blue and then back to black again if placed in alcohol.[94] Blue specimens, apparently of this species, have been described from tropical West Africa.[95]

92. Our description of the teeth of males is based on published accounts (Pellegrin, Bull. Soc. philom. Paris, [10] *4*, 1912: 97, fig. 3; Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 279, pl. 48, fig. 3). For discussion of abnormal teeth with photographs, see Gudger (J. Elisha Mitchell Sci. Soc., *49*, 1939: 92, pl. 2).
93. For details, see Leigh-Sharpe (J. Morph., *42*, 1926: 317–318, fig. 12).
94. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 342; Bull. Amer. Mus. nat. Hist., *35*, 1916: 653.
95. As *Cephaloptera rochebrunei*; see Synonyms, p. 494.

Size. Some are born when less than 550 mm wide (see Study Material), but it seems that others are not born until somewhat larger.[96] Females may mature when little more than $3^1/_2$ feet wide, for the state of the uterus of one 1,110 mm wide (about 44 in.) showed that she was gravid; no doubt she had expelled her young prematurely at the time of capture.[97] The claspers of a male about 45 inches wide (1,140 mm) appeared to be fully developed.[98] And "the width of adult specimens rarely exceeds four feet."[99]

Developmental Stages. Embryos, when nearly ready for birth, closely resemble their parents and lie with one pectoral rolled around the other.[100] Earlier stages have not been described nor have we seen any. In the only reported case, a female contained one embryo only. In gravid females, the walls of the uterus are clothed with the "characteristic vascular villi. The uterine milk is greenish."[101]

Habits. The Lesser Devil Ray feeds chiefly on planktonic crustacea and to a lesser extent on small schooling fishes. The contents of the few stomachs examined consisted of either small mysid-like shrimps or striped salt-water minnows (*Fundulus majalis*) which are plentiful along the beaches of North Carolina where the observations were made.[102] The method of feeding was observed long ago at Jamaica, where this Ray was described as pushing its way through the so-called turtle grass; "it takes into its wide mouth the congregated living things that are in its way," while "its head fins .... direct the food to the mouth."[103] When in pursuit of a school of minnows, they are described as "rushing right up on the sand .... until their bodies were nearly half out of water; but in an instant they were off and scattered out to sea."[104] When swimming quietly they keep their cephalic fins tightly curled so that they point forward like horns. But when pursuing a school of minnows, the fins "open and, meeting below the mouth, form a funnel, through which the 'minnows' are carried into the mouth. On the instant that this rush is over these fins again close up tightly."[105]

Those that reach the North Carolina Coast are described as travelling in schools; they are capable of swimming at high speed and they often leap high above the surface. They are said to utter a bell-like bark when captured,[106] but it is not known whether they make any sounds while in the water.

Gravid females have been taken both in Jamaican waters and near Cape Lookout, North Carolina, showing that they may produce young anywhere within their geographic range. The male of a pair observed while mating "was above with back just showing above the water and his wing-like pectorals curved upward .... while the female

96. An embryo 16 inches wide has been reported (Hill, Intell. Observ., *2*, 1862: 167).
97. Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 280.
98. Leigh-Sharpe, J. Morph., *42*, 1936: 317, fig. 12.
99. Coles, Bull. Amer. Mus. nat. Hist., *35*, 1916: 654. We find no definite record of a measured specimen wider than four feet.
100. See Hill (Intell. Observ., *2*, 1862: 176) for illustration of embryo with left-hand pectoral rolled around the right-hand one.
101. Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 280.
102. Ten stomachs examined (Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 242; Copeia, 32, 1916: 45–46; Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 280).
103. Hill, Intell. Observ., *2*, 1862: 170.
104. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 341.
105. Coles, Bull. Amer. Mus. nat. Hist., *35*, 1916: 652.
106. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 343.

was oriented so as to plainly show the white side uppermost, with pectorals standing up."[107]

At Cape Lookout, the most northerly locality on the Atlantic Coast of the United States where the presence of this Ray has been established definitely, the dates of occurrence have been confined to the last three weeks of July. No doubt it occurs the year round in the more tropical part of its range.

Numerical Abundance. Nothing is known as to the numbers of the Lesser Devil Ray either off the Brazilian Coast or in the Caribbean. The numbers caught yearly in July on the North Carolina Coast near Cape Lookout from 1912 to 1914 ranged between 9 and 21, with a total catch of about 75 for the five years.

Relation to Man. The flesh, light red in color, is described as having an excellent flavor.[108] But the numbers taken are not large enough anywhere for it to be of commercial value, even if its desirability as a food fish were appreciated.

Range. Coastal waters of western Atlantic, Brazil northward regularly to Cape Lookout, North Carolina,[109] perhaps straying to New Jersey; also Coast of Senegal, West Africa.

Occurrence in the Western Atlantic. The presence of *Mobula hypostoma* has been positively established only at Santos, Brazil;[110] Jamaica; Lemon Bay, western Florida; New Smyrna Beach, eastern Florida (see Study Material, p. 488); and Cape Lookout, North Carolina. But the distribution of these localities shows that it is to be expected anywhere on the Atlantic Coast of America between about Lat. 24–25° S and 34–35° N. The fact that one or more schools were sighted near Cape Lookout every July for several years during the period from 1910 on suggests that at least a few may be expected to wander northward as far as that every summer. It has been reported from the coast of New Jersey also,[111] but the specimen in question was so large (9 ft. wide) that it may have been a *Mobula mobular* that had strayed across the Atlantic (p. 496).

Synonyms and References:

Cephalopterus hypostomus Bancroft, Proc. zool. Soc. Lond., 1831: 134 (descr., Jamaica); Zool. J. (1832–1834), *5*, 1835: 411 (diagn., Jamaica).

Cephaloptera olfersii Müller, Abh. Akad. Wiss. Berl., 1834: 311 (Brazil; not seen); Müller and Henle, Plagiost., 1841: 185 (descr., meas., size, Brazil); Duméril, Hist. Nat. Poiss., *1*, 1865: 657, pl. 6, fig. 8 (descr., color, size, ill. teeth, Brazil).

Cephaloptera massenoidea Hill, Intell. Observ., *2*, 1862: 162–176 (name, ill. embryo, capture, size, Jamaica, descr., feeding habits).

Dicerobatis olfersii Günther, Cat. Fish. Brit. Mus., *8*, 1870: 497 (descr., Brazil); Leigh-Sharpe, J. Morph., *42*, 1926: 218, 317 (ill. claspers).

Cephaloptera rochebrunei Vaillant, Bull. Soc. philom. Paris, (7) *3*, 1879: 171 (descr., color, size, Senegal); Rochebrune, Act. Soc. linn. Bordeaux, (4) *6*, 1882: 58, pl. 1, figs. 1, 2; also Faune Senegambie, 1, Poiss.,

107. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 343–344.

108. Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 342.

109. Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 453) gave the range as "Brazil to New York." It has been suggested by Whitley (Aust. Zool., *8*, 1936: 187) "that Garman's beautiful figures were probably made from New York specimens." Actually they were drawn from a Brazilian specimen (Harv. Mus. Comp. Zool., No. 683) collected many years ago, a companion of which we have seen.

110. Also reported from Brazil without definite locality.

111. Fowler, Fish Culturist, *9*, 1930: 115.

1883–1885: 35, pl. 1, figs. 1, 2 (descr. after Vaillant 1879, color, ills., Senegal); Pellegrin, Bull. Soc. philom. Paris, (10) *4*, 1912: 96 (type in Paris, sexual diff. in teeth).

Dicerobatus olfersii Garman, Bull. Mus. comp. Zool. Harv., *17*, 1888: 105, pls. 52, 53 (mucous canal syst.).

Aodon hypostomus Jordan and Evermann, Bull. U. S. nat. Mus., *47* (1), 1896: 92 (diagn., Jamaica by ref. to Bancroft 1831); Rep. U. S. Comm. Fish. (1895), 1896: 225 (listed, Jamaica).

Mobula olfersi[112] Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 194, 212 (descr., after Müller and Henle 1841, refs., Brazil); Gill, Smithson. misc. Coll., *52*, 1908: 176 (listed, Brazil and Caribbean); Coles, Bull. Amer. Mus. nat. Hist., *28*, 1910: 341–342 (nos., season, habits, C. Lookout, N. Carolina); Pellegrin, Bull. Soc. philom. Paris, (10) *4*, 1912: 94 (photos, descr., teeth, C. Lookout, N. Carolina); Coles, Bull. Amer. Mus. nat. Hist., *32*, 1913: 33 (embryo, nos., season, C. Lookout, N. Carolina); Gudger, J. Elisha Mitchell Sci. Soc., *28*, 1913: 161 (size of uterus, habits, nos., C. Lookout, N. Carolina); Proc. biol. Soc. Wash., *26*, 1913: 102 (embryo, nos., season, C. Lookout, N. Carolina by ref. to Coles 1910, 1913); Radcliffe, Science, N. S. *38*, 1913: 396 (listed, Beaufort, N. Carolina); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (nos., season, C. Lookout, N. Carolina); Copeia, 32, 1916: 45–46 (feeding habits, stom. contents, C. Lookout, N. Carolina); Bull. Amer. Mus. nat. Hist., *35*, 1916: 650 (nos., color change after death, habits, embryos, C. Lookout, N. Carolina); Ribeiro, Rev. Mus. paul., *10*, 1918: 708 (listed, Santos, Brazil); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 49 (descr. after Müller and Henle 1841, Brazil); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 39 (W. Indies, Caribbean N. to New York); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 32 (listed, C. Lookout to Brazil); Gudger, Sci. Mon. N.Y., *34*, 1932: 412 (eaten by sharks, by ref. to Bell and Nichols 1921); Whitley, Aust. Zool., *8*, 1936: 187 (perhaps distinct from *M. hypostoma*); Fowler, Fish Culturist, *21* (9), 1942: 66 (listed, Cuba).

Cephaloptera massenoides Gudger, Proc. biol. Soc. Wash., *25*, 1912: 149 (embryo, by ref. to Hill 1862).

Mobula hypostoma Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 453 (descr.), pl. 54, fig. 6 (pelvis), pl. 57, fig. 6 (heart), pl. 59, figs. 7–8 (gills), pl. 75 (skel.); Radcliffe, Trans. Amer. Fish. Soc., *44*, 1914: 38 (sex diff. in teeth, N. Carolina); Bull. U. S. Bur. Fish., *34*, 1916: 279, pls. 48, 49 (meas., descr., teeth, stom. contents, photos, C. Lookout, N. Carolina); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 93 (descr., refs.); Jordan, Manual Vert. Anim. NE U. S., 1929: 20 (diagn., N. Carolina to Brazil); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 32 (listed, Jamaica); Bere, Amer. Midl. Nat., *17*, 1936: 582, 590, 596 (copepod parasites, Lemon Bay, W. Florida); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 142 (color diff. from *M. rochebrunei*); White, Bull. Amer. Mus. nat. Hist., *74*, 1937: 91 (no. heart valves, after Garman 1913); Whitley, Aust. Zool., *8*, 1936: 187 (refs., perhaps distinct from *M. olfersi*); Norman and Fraser, Giant Fishes, 1937: 84 (listed, W. Atlant.); Hildebrand, Copeia, 1941: 222 (listed, C. Lookout, N. Carolina); Fowler, Monogr. Acad. nat. Sci. Philad., 6, 1944: 456 (listed, Jamaica).

Mobula hypostomus Fowler, Proc. biol. Soc. Wash., *33*, 1920: 146, footnote 6 (no record for New Jersey).

Mobula hypostoma (*olfersi*) Gudger, J. Elisha Mitchell Sci. Soc., *49*, 1933: 92, pl. 2 (abnormal dentition, photos, tooth bands).

Mobula rochebruni Whitley, Aust. Zool., *8*, 1936: 187 (refs., color, teeth, Senegal, by ref. to Garman 1913).

Mobula rochebrunei Whitley, Aust. Zool., *9*, 1939: 259 (no. teeth).

Doubtful Synonym:

Mobula hypostoma Fowler, Fish Culturist, *9*, 1930: 115 (New Jersey specimen 9 ft. wide, perhaps *M. mobular* because of large size; see p. 497).

Mobula mobular (Bonnaterre) 1788

Devil Ray

Study Material. None.

Distinctive Characters. *Mobula mobular* of the eastern Atlantic differs chiefly from *M. hypostoma* of the western Atlantic in being much larger, growing to a width of

112. Sometimes spelled *olfersii* or *ölfersii*.

16–17 feet or more,[113] in having a tail spine (or spines?) and in having prickles on the tail posterior to the dorsal fin.

Remarks. Normally this Devil Ray appears to be confined to the Mediterranean and to the neighboring parts of the eastern Atlantic, from Ireland (p. 487), northern Spain,[114] and Portugal[115] to the Azores, Canaries, and tropical West Africa.[116]

Our only reason for mentioning this Devil Ray here is that a *Mobula* nine feet wide was taken off New Jersey in 1929 and another, 12 feet from tip to tip, was harpooned near Havana, Cuba in July 1932;[117] these specimens were so large that they seem to us more likely to have been examples of *M. mobular* from across the Atlantic than to have been giant specimens of *M. hypostoma*. The same may apply to the Raie manatia of Lacépède 1798, based on a specimen nine feet wide from equatorial America, though the illustration of it was partly fanciful (see References, p. 497).

Synonyms and Possible Western Atlantic References:

Raie cornue . . . Duhamel, Traité Pêches, *4* (9), 1782: 293, pl. 17 (descr., ill., Medit. near Marseilles).

Raia mobular Bonnaterre, Tabl. Encyc. Meth. Ichthyol., 1788: 5 (descr. by ref. to the Raie cornue of Duhamel, 1782, Medit.).

Raie mobular, Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 33, 151 (descr., Medit., Azores, by ref. to Duhamel, 1782).

Raja fabroniana Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *2*, [An. VIII] 1799–1800: 104, 111, pl. 5, figs. 1, 2 (descr., ill., Medit.).

Raja cephaloptera Bloch and Schneider, Syst. Ichthyol., 1801: 365 (diagn., after Duhamel, 1782).

Raja giorna Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *5*, [An. XI] 1802–1803: 662, 666, pl. 20, fig. 3 (descr., ill., Medit.).

Grande raie, Giorna, Mem. Accad. Sci. Turin, *2*, 1805: 4 (descr., Medit.).

Mobula auriculata Rafinesque, Indice Ittiol. Sicil., 1810: 48 (for Raie mobular Lacépède 1798).

Apterurus fabroni Rafinesque, Indice Ittiol. Sicil., 1810: 48 (name only, equals *Raja fabroniana* Lacépède 1799–1800).

Cephalopterus giorna Risso, Ichthyol. Nice, 1810: 14 (descr., Medit.).

Cephalopterus massena Risso, Ichthyol. Nice, 1810: 15 (descr., Medit.).

Dicerobatus mobular Blainville, Bull. Soc. philom. Paris, 1816: 112 (name only, doubtless equals *Raia mobular* Bonnaterre 1788).

Dicerobatus fabronianus Blainville, Bull. Soc. philom. Paris, 1816: 112 (name only, doubtless equals *Raja fabroniana* Lacépède 1799–1800).

Dicerobatus giornanus Blainville, Bull. Soc. philom. Paris, 1816: 112 (name only, doubtless equals *Raja giorna* Lacépède 1802–1803).

Dicerobatus massena Blainville, Bull. Soc. philom. Paris, 1816: 112 (name only, doubtless equals *Cephalopterus massena* Risso 1810).

Cephaloptera giorna Cuvier, Règne Anim., *2*, 1817: 138 (name only, equals *Raja giorna* Lacépède 1802–1803).

113. See Rey (Fauna Iberica, Peces, *1*, 1928: 657) for a photograph of one 4.55 meters (14 ft. 11 in.) wide, weighing 358 kilograms (788 lb.), taken on the southeast coast of Spain in 1916. Also, there is (or was) a mounted *M. mobular* from the Mediterranean about 5 meters wide (16½ ft.) in the Paris Museum, and a 5.2 meter (17 ft.) Devil Ray has been taken at Oran, Algeria, provisionally identified from photographs as being of this species (Pellegrin, Bull. Mus. Hist. nat. Paris, *7*, 1901: 327–328). The Mediterranean specimen that formed the basis of the species *M. mobular* was said to have been 15 feet 10 inches wide, 6 feet for each wing and 46 inches for the trunk between (Duhamel, Traité Pêches, *4* [9], 1782: 293, pl. 17; Bonnaterre, Tabl. Encyc. Meth. Ichthyol., 1788: 5). Another large Mediterranean specimen, 3.49 meters wide, was also reported many years ago (Risso, Hist. Nat. Europe Merid., 3, 1823: 154).

114. Rey, Fauna Iberica, Peces, *1*, 1928: 656.

115. Nobre, Fauna Marinha Port. Vert., *1*, 1935: 492.

116. Reported south to Senegal as *Cephalopterus giornae* by Belloc (Rev. des Trav. Pêches Marit., *7* [2], 1934: 178).

117. Personal communication from Luis Howell-Rivero.

Diecrobatis mobular Blainville, in Vieillot, Fauna Franç., Poiss., 1825: 41, pl. 8, figs. 1, 2 (descr., meas., [ill. not seen], Medit.).
Pterocephalus massena Swainson, Nat. Hist. Fish. Amphib. Rept., 1, 1838: 170 (name only, equals *Cephalopterus massena* Risso 1810).
Pterocephala giorna Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1839: 321 (name only, equals *Raja giorna* Lacépède 1802–1803).
Pterocephala fabroniana McCoy, Ann. Mag. nat. Hist., *19*, 1847: 176, pl. 11 (descr., ill. S. Ireland).
Cephaloptera massena Hill, Intell. Observ., *2*, 1862: 167 (by ref. to Risso, 1810).
Cephaloptera fabroniana Duméril, Hist. Nat. Poiss., *1*, 1865: 658 (diagn., Medit.).
Dicerobatis giornae Günther, Cat. Fish. Brit. Mus., *8*, 1870: 496 (diagn., refs., Medit.).
Mobula mobular Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 450 (descr., refs.).

Doubtful Synonyms:

Squalus edentulus Brünnich, Ichthyol. Massil., 1768: 6 (descr., dried head, no lower teeth, no definite local.).
Aodon cornue, Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 33, 151 (descr. after Brünnich, 1768, *Squalus edentulus*).

Possible American Synonyms and References:

Raie manatia, Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *1*, 1798: 160, pl. 7, fig. 2 (specimen 9 ft. wide, apparently *Mobula* because of position of mouth, but ill. shows forked caudal, equat. America).[118]
Raja manatia Bloch and Schneider, Syst. Ichthyol., 1801: 364 (descr. by ref. to Raie manatia, Lacépède, 1798).
Mobula hypostoma Fowler, Fish Culturist, *9* (8), 1930: 115 (good photo, New Jersey specimen 9 ft. wide; perhaps *M. mobular* because of size).

Genus *Ceratobatis* Boulenger 1897

Ceratobatis Boulenger, Ann. Mag. nat. Hist., (6) *20*, 1897: 227; type species, *C. robertsii*. Jamaica.

Probable Generic Synonym:

Squalus, Brünnich, Ichthyol. Massil., 1768: 6; for *S. edentulus* Brünnich, dried head with cephalic fins, but no teeth in lower jaw; no stated locality.

Generic Characters. Mouth on lower surface of head, with teeth in the upper jaw only. Other characters as in *Mobula*.

Range. Known definitely from only a single specimen from Jamaica.

Species. C. robertsii Boulenger 1897, from Jamaica; perhaps also the *Squalus edentulus* of Brünnich, 1768, locality not known.

Remarks. It is possible that the only known specimen actually is an aberrant *Mobula hypostoma* that failed to develop teeth in the lower jaw.[120] But since it seems to be normal in all other respects, and since another mobulid without lower teeth was reported many years ago, the genus *Ceratobatis* is accepted here provisionally.

Ceratobatis robertsii Boulenger 1897

Figure 115

Study Material. None. One female (type), 770 mm wide (approximtae measurement), not seen by us, from Jamaica, in British Museum [Natural History].[121]

118. Referred by Garman (Mem. Harv. Mus. comp. Zool., *36*, 1913: 454) to synonymy of *Manta birostris*.
120. Miss Ethelwyn Trewavas, who examined the specimen in the British Museum, corroborates the original statement that it has teeth in the upper jaw only.
121. Collected by Rev. Seed-Roberts.

Distinctive Characters. This Devil Ray closely resembles *Mobula hypostoma* in general appearance as well as in the position of the mouth; but it is set apart from *Mobula* and from all other Devil Rays by having no teeth on its lower jaw.

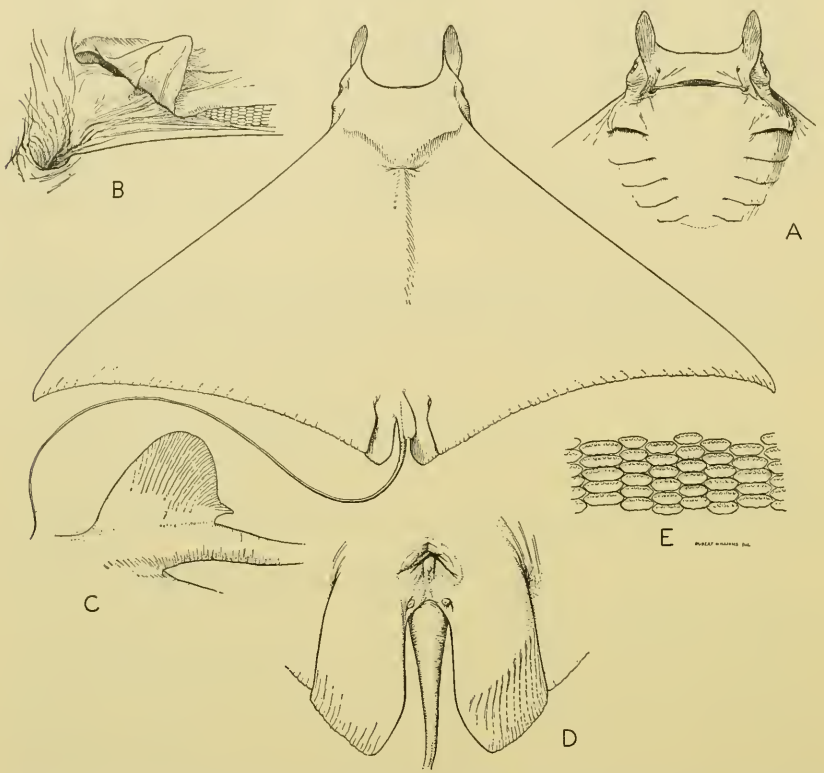

FIGURE 115. *Ceratobatis robertsii*, female, 770 mm wide, from Jamaica (British Museum [Natural History]). *A* Lower surface of head. *B* Right-hand nostril with nasal curtain rolled back, and outer part of tooth band. *C* Side view of dorsal fin. *D* Ventral view of pelvic fins. *E* Teeth. Drawings by Hubert Williams.

Description.[122] Proportional dimensions in per cent of extreme breadth of disc. Female, 770 mm broad, from Jamaica (Brit. Mus. [Nat. Hist.], type, 1897. 7. 1. 40).

Disc: length 51.5.

Snouth length: in front of mouth 3.6.

122. Based on measurements and notes by Miss Ethelwyn Trewavas, British Museum [Natural History], and on drawings by Hubert Williams, of the type specimen.

Orbits: horizontal diameter 2.9; distance between 17.2.
Spiracles: length 0.5.
Mouth: breadth 13.5.
Exposed nostrils: distance between inner ends 11.0.
Gill openings: lengths, 1st 5.6; 3rd 6.0; 5th 4.3; distance between inner ends, 1st 14.3; 5th 3.3.
Dorsal fin: vertical height 4.5; length of base 5.6.
Pelvics: anterior (outer) margin 4.2.
Distance: from tip of snout to center of cloaca 43.5.

Disc, exclusive of cephalic fins, a little more than 2.3 times as broad as long, with well marked mid-dorsal crest from head to pectoral girdle; its thickness at pectoral girdle about 11 % as great as its extreme breadth. Tail from center of cloaca about as long as disc, tapering regularly and ending in a slender filament;[123] laterally compressed, about 1.7 times as high as wide at posterior end of dorsal fin; its sides flat rearward from dorsal fin; its upper surface with a faintly indicated ridge extending for a short distance rearward from close behind dorsal fin.

No tail spine.

Skin along median belt from head to dorsal fin and on lateral parts of disc rough with minute prickles, each with bifid base, smaller and sparser anteriorly than posteriorly; dorsal surfaces of pectorals also with some prickles, at least posteriorly. Ventral surface of snout, of abdomen and of posterior parts of pectorals with similar minute prickles.

Head weakly convex transversely, without longitudinal depression; its thickness at level of mouth a little more than 1/3 (about 38 %) as great as distance between eyes; its dorsal profile sloping forward to sharp front margin; its anterior contour evenly concave. Orbit occupying entire side of head (except base of cephalic fin); exposed part of eye circular, its diameter about half as great as diameter of orbit. Spiracle directed rearward, appearing as a crescentic slit, lying in a groove, outlined above by a ridge extending forward nearly to above eye; distance of spiracle from eye nearly twice as great as diameter of eye. Anterior margins of gill openings weakly convex (front to rear); second and third (longest) about half as long as distance between outer ends of nostrils; fifth about 3/4 (74 %) as long as third. Nasal openings oblique, all but their outer ends concealed by nasal curtain; distance between outer ends of nostrils a little more than half of width of head at level of mouth;[124] outer-posterior margin of nostril with a low subtriangular lobe extending inward over nasal aperture, only its anterior edge visible unless nasal curtain is turned back; an elliptical area behind this lobe (normally hidden by the nasal curtain) covered by thin skin with large melanophores surrounded by a halo of sparser, smaller melanophores; nasal curtain with its outer corner a little less than a right angle, its free posterior margin forming a slightly concave free lip, its lower surface, near outer margin, crossed by an oblique fold facing mouth, perhaps acting as

123. The tail has been repaired midway of its length on the unique specimen, but it appears to be intact otherwise.
124. About 53 % in preserved state.

a valve (Fig. 115B). Mouth occupying about $^2/_3$ of width of head; edge of lower jaw bowed slightly forwards. Tooth band of upper jaw narrowly fusiform, occupying a little less than half (45 %) of breadth of mouth; its length (anteroposteriorly) about 14–15 % as great as its transverse breadth.

Upper teeth in 36 series; each tooth with a sharp posterior edge, sometimes scalloped in two to four blunt lobes, and with a tuberculated anterior edge. No teeth in lower jaw, and no trace of teeth below the skin.

Cephalic fins about 1.4 times as long as broad (their length measured from mouth); their dorsoventral axes sloping slightly outwards from above to below, their bases terminating about under spiracles at level of lower surface of head; their anterior margins turned towards axial plane of body (in preserved state). Main portions of pectorals originating close behind spiracles immediately above level of latter; their anterior margins weakly convex, increasingly so toward outer corners; their posterior margins slightly concave; inner margins overlapping pelvic fins, moderately convex toward axils; outer corners narrowly pointed, as illustrated (Fig. 115); rear corners angular, a little less than a right angle (75–80°). Dorsal fin of shape illustrated (Fig. 115); its free rear corner about even with midpoints of inner margins of pelvics. Pelvics extending only a little beyond posterior corners of pectorals; outer margins nearly straight, posterior outline wedge-shaped (Fig. 115D).

Color. Upper surfaces of disc, pelvics and dorsal fin, and upper surface and sides of tail, blackish brown after preservation for many years, the dark shade extending down sides of head to surround eyes, more diffuse behind eyes than around their rims. Upper margins and in-turned distal portions of cephalic fins also dark, their out-turned surfaces whitish; lower surfaces of disc, pelvics and proximal portion of tail whitish.

Size. The single known specimen (type) is only 770 mm wide.

Habits. Nothing whatever is known of its way of life.

Range. The only known specimen was from Jamaica.

References:

Ceratobatis robertsii[125] Boulenger, Ann. Mag. nat. Hist., (6) *20*, 1897: 227 (descr., meas., size, color, Jamaica); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (*3*), 1898: 2756 (descr., meas., size, color, Jamaica, from Boulenger, 1897); Gill, Science, N. S. *18*, 1903: 473 (discuss., by ref. to Boulenger 1897); Smithson. misc. Coll., *52* (2), 1898: 176 (length of tail); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 454 (descr., from Boulenger, 1897); Jordan, Evermann, and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 32 (listed, Jamaica); Whitley, Aust. Zool., *8* (3), 1936: 188 (listed, by ref. to Boulenger, 1897).

Possible Synonym:

Squalus edentulus Brünnich, Ichthyol. Massil., 1768: 6 (dried head with cephalic fins, but no teeth in lower jaw; local. not stated).

Genus *Manta* Bancroft 1828

Manta Bancroft, Zool. J., *4*, 1828: 454; type species, *M. americana* Bancroft. Jamaica.

125. Sometimes spelled *robertsi*.

Generic Synonyms:

Raja (in part) Walbaum, P. Artedi Genera Pisc. Emend. Ichthyol., *3*, 1792: 535; for *R. birostris* Walbaum. No locality.[126]

Cephalopterus Mitchill, Ann. New York Lyc., *1*, 1824: 23, pl. 2, fig. 1; for *C. vampyrus* Mitchill. Off Delaware Bay.

Cephaloptera Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 115; for *C. giorna* Lesueur (not Lacépède, 1802–1803). Off Delaware Bay.

Ceratoptera Müller and Henle, S. B. Akad. Wiss. Berl., 1837: 118; Plagiost., 1841: 186, 198; type species, *C. johnii* Müller and Henle. Jamaica.[127]

Brachioptilon Newman, Zoologist, *7*, 1849: 2358; type and only included species, *B. hamiltoni* Newman. Gulf of California.

Diabolicthys Holmes, Proc. Elliott Soc. nat. Hist., *1*, 1856: 45; type and only included species, *D. elliotti* Holmes. Charleston, S. Carolina.

Deratoptera Krefft, Ill. Sydney News, *5*, 1868: 3, 9; type species, *D. alfredi* Krefft. New South Wales. Not seen.[128]

Diabolichthys Marshall, Nomencl. Zool., 1877: 72; emended spelling for *Diabolicthys* Holmes 1856. Not seen.

Daemomanta Whitley, Rec. Aust. Mus., *18* (6), 1932: 327; type species, *Manta alfredi* Stead 1906.[129] New South Wales.

Desmomanta Fowler, Mem. Bishop Mus., *11* (6), 1934: 386; in refs., misspelling for *Daemomanta* Whitley 1932.

Not *Cephalopterus* Risso, Ichthyol. Nice, 1810: 14; equals *Mobula* Rafinesque 1810; preoccupied, see p. 486, footnote 73.

Not *Cephaloptera* Cuvier, Règne Anim., *2*, 1817: 138; equals *Mobula* Rafinesque 1810.

Generic Characters. Mobulidae with mouth extending across front of head, not on its lower surface. Tail with or without a serrate spine. Teeth in lower jaw only. Transverse pinnations along distal margin of each branchial plate fused at their tips with those of each adjacent plate, thus forming an exceedingly close-meshed net or gridwork (p. 482, Figs. 111, 112). Other characters as in *Mobula*, so far as known.

Size. This genus includes the largest of modern Rays, which grow to a width of at least 22 feet and to a weight of more than 3,000 pounds.

Range. Tropical-subtropical belts in both hemispheres; Red Sea and Indian Ocean region from northern parts of Arabian Sea (Karachi) and Bay of Bengal (Puri) south to Natal and South Africa (Table Bay); Malay Peninsula and East Indies; Queensland and New South Wales, Australia; island groups of tropical-subtropical Pacific, north to Hawaii and south to the Marquesas and Mangareva of the Gambier group (Lat. 23° 07′ S);[130] west coast of America from southern California (near San Pedro) to Peru;

126. References by Walbaum were to the Diabolus marinus of Willughby (Hist. Pisc., Append., 1686: 5, pl. 9, fig. 3), no locality; to the Divel Fish of Pennant (Arctic Zool., Suppl., 1787: 104), which seems to have been a *Mobula*, however, because it referred to Duhamél's (Traité Pêches, *4* [9], 1782: 293, pl. 17) Raie cornue, which certainly was; and to the Devil Fish of Catesby (Nat. Hist. Carolina, *1*, 1731: XXXII), Carolina.

127. *Cephalopterus vampyrus* Mitchill 1824 was designated as the type species by Jordan (Genera Fish., 1, 1917: 193), but *Cephaloptera giorna* Lesueur 1824 was designated by Fowler (Bull. U. S. nat. Mus., 100 [13], 1941: 483). However, the only mention of either of them by Müller and Henle was as synonyms of their *Ceratoptera johnii*. Therefore it seems preferable to select the latter as the type of their genus *Ceratoptera*.

128. Cited from Fowler (Bull. U. S. nat. Mus., 100 [13], 1941: 484).

129. Whitley (Rec. Aust. Mus., *18*, 1932: 328) characterizes all mention of the Australian *alfredi* prior to 1906 (Stead, Fish. Aust., 1906: 238) as *nomina nuda*, and hence not to be taken into account. We cannot judge whether this applies to the earliest mention of it as *Deratoptera alfredi* in 1868 by Krefft (Ill. Sydney News, 5: 3, 9), which we have not been able to consult.

130. In January 1905, while looking down from the precipitous peak of Mangareva (Mt. Duff) at an elevation of about 1,300 feet, we had the good fortune of watching two giant Rays swimming in the lagoon below us.

western Atlantic from vicinity of Rio de Janeiro to South Carolina and as a stray to southern New England (Block I.) and Georges Bank; also Bermuda;[131] Madeira,[132] and recently reported from tropical West Africa (p. 511), but not known otherwise from the eastern Atlantic.

Species. All records of *Manta* from the Atlantic appear to refer to a single species, *M. birostris* (Donndorff) 1798; the earliest reported locality for it was the coast of South Carolina (see p. 512, footnote 179). The earliest report of a Devil Ray from the Indo-Pacific, referable with certainty to *Manta* and not to its close relative *Mobula*, was from the Red Sea in 1841 as *Ceratoptera ehrenbergii* Müller and Henle.[133] Since that time Mantas have been reported from the western Pacific-Indian ocean area as ten additional species, supposedly distinct from *Manta birostris*;[134] and two more species have been reported from the Pacific Coast of America.[135]

The Mantas from all parts of the world resemble one another so closely in general appearance that all of the supposed species that have been named from the western Pacific-Indian Ocean region have been united recently with the Atlantic *Manta birostris* under that name.[136] But *Manta hamiltoni* of the Pacific Coast of Central America may prove separable from *M. birostris* of the Atlantic[137] by its color pattern. It would not be astonishing should the *Manta* populations of different parts of the tropical oceans be separated by morphological differences that are not apparent from the superficial accounts of them that have appeared so far. The question can be settled only by critical comparative study of actual specimens, which is a difficult matter because Mantas are so large and are so seldom captured under conditions that favor detailed examination of them.

Manta birostris (Donndorff) 1798

Giant Devil Ray

Figures 111, 112, 116, 117

Study Material. Juvenile male, 11 feet 5 inches wide, and parts of a female about 15 feet wide, from Bimini, Bahamas, in Harvard Museum of Comparative Zoology; also model, with photographs, of female about 17 feet wide, from west coast of Florida, in American Museum of Natural History; sketches, measurements, color notes, drawings, and photograph by F. Huber of a female 21 feet 2 inches wide, taken August 27, 1933 off Pt. Pleasant, New Jersey.

Distinctive Characters. The cephalic fins of *Manta*, projecting forward, give it so

131. Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 278. 132. Maul, Lista Sist. Peixes Madeira, 1949: 140.
133. Plagiost., 1841: 187. The *Raja banksiana* of Lacépède (Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *2*, [An. VIII] 1799–1800: 115, pl. 5, fig. 3) from the East Indies is also classed as a *Manta* by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 483). But it may have been a *Mobula*, for no information is available as to the position of its mouth.
134. For references, see Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 483) under *Manta birostris*.
135. *Manta raya* Baer 1899 (Bull. Mus. Hist. nat. Paris, *5*, 1899: 112) from Peru and *Manta hamiltoni* (Newman) 1849 from California and Central America; see Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 274) for references.
136. By Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 483).
137. Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 276; Barton, Copeia, 1948: 146.

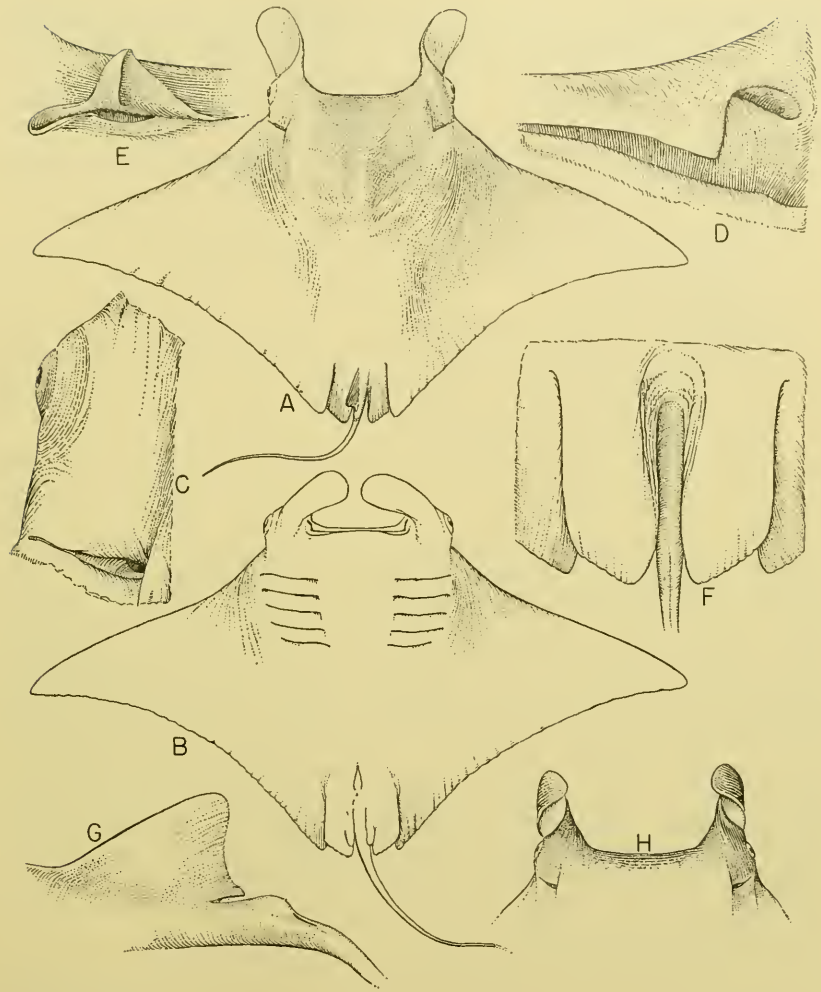

FIGURE 116. *Manta birostris*. *A* Dorsal view, based on juvenile male, 11 feet 5 inches wide, from Bimini, Bahamas. *B* Ventral view of same. *C* Left-hand eye and spiracle of same, about 0.25×. *D* Left-hand nostril and outer part of right-hand nasal curtain of same. *E* Outer part of right-hand nasal curtain of same rolled forward to show transverse fold on internal surface. *F* Pelvic fins of female, about 15 feet wide, about 0.15×. *G* Dorsal fin and base of tail of same, about 0.15×. *H* Front of head of female, about 21 feet 2 inches wide, taken off New Jersey, to show cephalic fins coiled in swimming position; from photograph by F. Huber.

distinctive an appearance that it could not be confused with any other Atlantic Ray except some other member of its own family. The position of its mouth, extending across the front of its head instead of on the lower surface, sets it apart from both *Mobula* and *Ceratobatis*, if the latter be a valid genus. The fact that it has no teeth in the upper jaw distinguishes it from the somewhat problematical genus *Indomanta* (see discussion, p. 485).

Description. Proportional dimensions in per cent of extreme breadth. Male, 3,480 mm broad, from Bimini, Bahamas (Harv. Mus. Comp. Zool., No. 37006).

Disc: vertical length 44.5.
Orbits: horizontal diameter 2.4;[138] distance between 24.8.
Spiracles: length 1.6; distance between 20.8.
Mouth: breadth 14.9.
Nostrils: distance between outer ends 14.1.
Gill openings: lengths, 1st 9.8; 2nd 10.1; 3rd 9.8; 4th 8.8; 5th 7.0; distance between inner ends, 1st 10.8; 5th 5.1.
Dorsal fin: vertical height 4.4; length of base 5.3.
Pelvics: anterior (outer) margin 6.2.
Distance: from center of snout to center of cloaca 36.5; from center of cloaca to tip of tail 37.6.

Disc, exclusive of cephalic fins, about 2.2 times as broad as long on specimens measured; main portions of pectorals originating about opposite spiracles or a little posterior; anterior margins of pectorals weakly concave and then becoming convex outwardly; posterior margins rather strongly concave; inner margins weakly convex; outer corners falcate, tapering to narrowly blunted tips; rear corners also narrowly rounded. Axis of greatest breadth about 58 % of distance rearward from front of midsector of head toward level of axils of pectorals. Maximum thickness of trunk described as being between 20 and 27 % as great as breadth of disc in specimen 15 feet wide,[139] but only 15 % as great as breadth of disc on one 21 feet wide.[140] Tail from center of cloaca at least as long as distance from cloaca to front of head and perhaps considerably longer in undamaged specimens,[141] tapering to slender tip; its height at rear end of dorsal fin between 1/4–1/3 (about 28 %) as great as length of base of dorsal; its sides somewhat flattened, with shallow longitudinal furrow along anterior quarter of its length, its upper surface with a low ridge reaching about equally far back, its lower surface with a similar ridge extending somewhat farther.

Some specimens are described as having one or two small serrated spines a little posterior to the dorsal fin.[142] However, the tails of other specimens (including those

138. The eye is 1.6.
139. Günther, Cat. Fish. Brit. Mus., *8*, 1870: 498.
140. Measurements contributed by Fred Huber.
141. The specimens seen by us have lost part of the end of the tail, as had most of those that have been described previously.
142. See Lesueur (J. Acad. nat. Sci. Philad., *4*, 1824: 117, pl. 6) for account of a 15–16 foot female from off Delaware Bay with one tail spine and of an embryo 1 foot 11 inches wide which was taken from her and which also had one

studied), though lacking emergent spines, have a prominent hard rounded protuberance or knob on the upper side close behind the dorsal fin and a shallow furrow about as long as the knob immediately behind it. The knob is supported internally by a small fusiform mass of bony tissue, the flattened lower surface of which is attached loosely to the muscular tissue of the tail. And the sloping posterior face of this bony mass bears a minute pointed spur (about $^1/_8$ in. long on a specimen 11 ft. wide) with serrate edges, the tip of which can be felt through the thin overlying skin on both specimens examined.[143]

Skin of disc, pelvics, and tail generally rough with small tubercles both above and below, without extensive bare areas except for a narrow naked zone along anterior margin of each pectoral; the tubercles on upper surface of disc and tail, on dorsal fin and on outer faces of cephalic fins ranging from conical to ridge-like on radiate bases, irregularly distributed, their bases nearly touching in some places but wider-spaced elsewhere; tubercles on lower surface about equally large, their bases oval and radially striate, the crests nearly horizontal and vertically truncate posteriorly; their longitudinal axes in general anteroposterior.

Head with a shallow triangular depression at anterior margin, its base forward; a prominent median crest from nape to shoulder region; otherwise nearly flat transversely; dorsal profile of anterior part of head approximately horizontal antero-posteriorly; anterior margin between cephalic fins weakly and evenly concave in somewhat half-elliptical outline; its vertical profile above mouth forming a narrow face about 5–6 % as high dorsoventrally as breadth of mouth; lower jaw projecting a little beyond upper anterior margin of head in weakly convex contour, thus conspicuous in dorsal view; margin of lower jaw thick and rounded.

Eyes high on sides of head and far forward, their centers a little anterior to level of midpoint of front outline of head; round, noticeably small; diameter of exposed eyeball about 5 % as great as distance between eyes; pupil round, about 40 % as wide as width of eyeball.

Spiracles on upper surface of head, their openings narrow-oval, nearly transverse or weakly oblique with outer ends anterior, about 1.4 times as long as eyeball, each continued outward as a narrowing furrow ending about level with upper edge of eyeball.

First and second gill openings nearly straight, third to fifth with anterior margins weakly convex rearward; second (longest) about 70 % as long as width of mouth; fifth about $^2/_3$ (67 %) as long as second; distance between inner ends of first gills about 72 % as great as breadth of mouth; distance between inner ends of fifth gills a little less than half as great as distance between first gills; fifth gill openings about half of distance back from front of head toward cloaca.

Exposed nasal openings a little inward from level of corners of mouth, noticeably

spine; see also Duméril (Hist. Nat. Poiss., *1*, 1865: 661) for a New York specimen about 8 feet 2 inches wide (2,500 mm) with two small tail spines.

143. For earlier accounts of specimens without tail spines but with similar knobs, see Mitchill (Ann. New York Lyc., *1*, 1824: 26) and especially Holmes (Proc. Elliott Soc. nat. Hist., *1*, 1859: 43–44, pl. 31), who has given excellent illustrations of the supporting bony mass with its rudimentary spine.

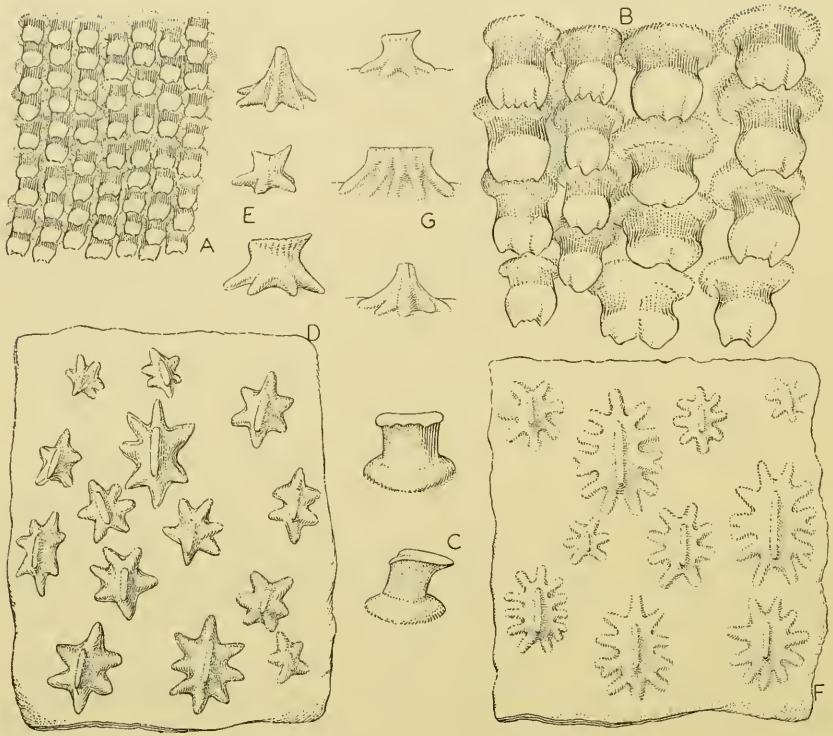

FIGURE 117. *Manta birostris*, juvenile male, 11 feet 5 inches wide. *A* Part of lower dental band from outer fifth of jaw, with anterior edge uppermost, about 5.7×. *B* Teeth from same, to larger scale, about 17×. *C* Lateral view (below) and posterior view (above) of tooth, about 17×. *D* Dermal denticles, dorsal surface, with anterior ends uppermost, about 12×. *E* Lateral views of larger and smaller denticles (below) with anterior ends to the left, and axial view (above), about 12×. *F* Dermal denticles from ventral surface with anterior ends uppermost, about 12×. *G* Lateral view of larger and smaller denticles from ventral surface (above), and axial view (below), about 12×.

small, their extreme breadth only about 5–6 % as great as breadth of mouth; outer contour of nasal curtain nearly rectangular with rounded corner; its rear margin smooth; weakly concave along median sector with the edge only narrowly free from upper lip; internal face of curtain, near outer end, with a thin transverse fold directed toward center of mouth (Fig. 116 E).

Mouth occupying more than half (about 63 %) of extreme breadth of head, its corners without distinct furrows; lower jaw weakly convex forward, somewhat overlapping upper jaw, its anterior edge thick, rounded; upper jaw without teeth, but upper

lip rough here and there with patches of denticles similar to those on upper surface of disc. Transverse curtain on roof of mouth conspicuous, far forward, its free edge posterior to edge of nasal curtain, centrally, by a distance only about 3.3 times as great as breadth of pupil; loose, flexible, forming an effective valve to prevent egress of water from mouth when walls of pharynx are contracted. Roof of mouth also with a low rounded longitudinal ridge extending rearward a short distance from opposite free edge of transverse curtain. Floor of mouth with a corresponding groove, narrowest anteriorly, broader posteriorly, reaching to point about opposite first gill cleft, interlocking with ridge on roof when mouth is closed; both roof and floor of mouth roughened with minute denticles.

Teeth of lower jaw (on specimens counted) in about 270 series in quincunx, about 18 rows along center of jaw decreasing to 12–14 rows toward corners, thus a total of about 4,800; teeth small, somewhat uneven in size, rounded to squarish as viewed from above, with flattened crowns pointing inward; their posterior margins often with 1–2 or more serrations; firmly set in a fleshy band, occupying about $^3/_4$ (73 %) of extreme lateral extent of jaw from which it is easily separated.

Cephalic fins about half as broad at base as long, their transverse axes nearly vertical on sides of head; upper margins about level with midpoint of front of head; lower origin on side of head about level with lower surface of head and a little posterior to eye; lower edges thin, upper edges thick, fleshy and rounded, their tips broadly rounded. The cephalic fins are rolled spirally (lower margins outward) when swimming or flattened vertically when feeding, and the outer ends are capable of being incurved so that the tips nearly meet; their shape as illustrated in Fig. 116. Dorsal fin originating a little anterior to axils of pectorals, the rear end of its base about opposite rear corners of pectorals and anterior to rear tips of pelvics by a distance about 40 % as long as its own base; anterior margin weakly convex; apex rounded; posterior margin slightly excavate with short free rear corner; base about $^1/_3$ (34 %) as long as breadth of mouth; vertical height about $^4/_5$ (83 %) as great as length of base. Pelvics with nearly straight margins, the outer (anterior) and inner margins nearly parallel, the posterior margin strongly oblique; corners rounded; anterior margin about 40 % as long as breadth of mouth. Claspers of immature male flat, fleshy, with rounded tips; their shape and length at sexual maturity not known.

For an account of the gill sieve, see p. 482 and Figs. 111, 112.

Color. Upper surface varying from reddish or olivaceous brown to black, slightly paler along margins; some specimens plain-colored; some with a white patch on each shoulder varying in shape and with or without a series of small dark spots across it;[144] some with two vaguely outlined whitish bands crossing disc obliquely rearward on either side, the more anterior of the pair close behind the eye;[145] still other individuals with a white triangular or chevron-shaped blotch on posterior part of disc in addition to the

144. Specimens with white markings have been described by Beebe and Tee-Van (Zoologica N. Y., *26*, 1941: 278) from Bermuda, and by Fowler (Fish Culturist, *21* [9], 1942: 6) from Cuba; for photographs of Florida specimens so marked, see Seager (Outing Mag., *39*, 1902: 560) and Holder (Big Game at Sea, 1908: pl. facing p. 24).

145. These pale bands are shown in the photograph included in our Study Material (p. 502).

white markings farther forward. While these pale patches appear to be normal in some cases, they may be accidental in others, for the dark superficial pigmentation is easily rubbed off. Outer (morphologically upper) surfaces of cephalic fins of same general color as back, shading to slate gray along edges. Lower surface, including inner (morphologically lower) surfaces of cephalic fins, white, either plain or with the abdomen irregularly and vaguely blotched with slaty gray or even black; margins of pectorals more or less widely edged with gray; mouth surrounded by a vaguely outlined band of the same dark hue.

An 11 foot 5 inch specimen, recently examined by us, was bluish slate above on disc and tail; dorsal fin edged with violet brown; outer faces of cephalic fins dark gray; lower surfaces of pectorals bluish gray around outer and posterior margins, but anterior margin narrowly edged with light gray; lower side of inner parts of pectorals and trunk, as a whole, pure white but marked with a large bluish gray blotch crossing the gill openings on each side; also four other dark gray blotches, of different sizes, irregularly arranged on abdomen; pelvics bluish gray toward tips; tail white close behind cloaca but gray thence rearward; lower tooth band white; inner parts of mouth, including gill sieve, dark gray.

A small one, observed in the aquarium at Bimini, showed some diurnal change in coloration; a pale patch appeared at night on each of the pectorals, which were uniformly dark by day.[146]

Size. A male 11 feet 5 inches wide was still immature, as shown by its small claspers which were a little short of the tips of the pelvics. But embryos have been found in females 14–15 feet wide, making it likely that it matures when it has grown to such a size. Commonly it reaches a breadth of 15–19 feet. One 19 feet 8 inches wide was reported recently off the mouth of the Mississippi,[147] one 21 feet 2 inches wide off New Jersey (see Study Material, p. 502), and one 22 feet wide and 17 feet long, evidently with tail damaged, was killed near Bimini in the Bahamas.[148] A specimen 14 feet wide and 7 feet from front of head to base of tail weighed 1,686 pounds, and a female 18 feet wide, from the Galapagos Islands, weighed 2,310 pounds.[149] The reported weight of 3,502 pounds for one 20 feet wide, taken many years ago at La Guayra, Venezuela, may not have been exaggerated, for the weight of the 22-foot Bahaman monster mentioned previously was above the limit of a commercial scale that weighed to 3,000 pounds.

Embryos, reported up to 50 inches wide, weighed 20 pounds or more.[150] But some are born while somewhat smaller than that, for free-living specimens have been reported as small as four feet wide.[151]

146. Breder, Bull. Amer. Mus. nat. Hist., *94* (2), 1949: 89.
147. Gowanloch, Bull. La. Conserv. Dep., 23, 1933: 241.
148. For account of the capture and size of this monster, with photographs, see La Gorce (Nat. geogr. Mag., *35*, 1919: 483–488), and Townsend (Bull. N. Y. zool. Soc., *22*, 1919: 140).
149. Beebe and Tee-Van, Zoologica N. Y., *26*, 1941: 275.
150. Müller and Henle (Plagiost, 1841: 187); Günther (Cat. Fish. Brit. Mus., *8*, 1870: 498). The 18-foot Galapagos *Manta* mentioned above contained an embryo 45 inches wide weighing 28 pounds.
151. Near the Grenadines, Lesser Antilles (Beebe and Hollister, Zoologica N. Y., *19*, 1935: 209). Henshall also reported

Developmental Stages. Beyond the fact that *Manta* is ovoviviparous, we only know that embryos which have reached a width of two feet or more resemble their parents closely and that a single embryo has been reported in each of the cases on record. In some cases gravid females have expelled their young prematurely on being harpooned.

Habits. It is only while they are swimming at the surface or basking there that Mantas are ordinarily encountered. We suspect that they spend much of their time resting quietly on bottom, otherwise they would be seen more regularly. When at the surface they often curl the tip of one pectoral or of both above water.[152] One, observed in an aquarium, was seen to use the cephalic fins as an aid in steering, turning them appropriately when making a sharp turn.[153] Sometimes they somersault, first lifting the head and part of the body out of the water, then revolving edgewise so that one pectoral emerges while the other sinks. At times they leap partly or wholly clear of the water and fall back with a resounding splash that is audible for a long distance in calm weather. We have often heard as many as three to five of them so engaged in an afternoon in the shallows between Cape Sable and Marco on the southwest coast of Florida.[154] They swim slowly, often in pairs, sometimes in companies, and they are so unwary that it is easy to approach one closely in a small boat. But they dart ahead at high speed when harpooned or otherwise disturbed. Large ones are so strong and so enduring, if they are not seriously injured, that accounts of their towing a skiff for hours have appeared repeatedly.[155]

The only firsthand statement of their stomach contents with which we are acquainted is that the South Carolina specimens contained "fragments resembling the shells of shrimps," one with a small crab. One was seen to gulp a school of small mullets into its capacious mouth.[156] Presumably they obtain their food, like the Lesser Devil Ray, by swimming open-mouthed through whatever schools of small fishes or planktonic crustacea they may meet. Charges that they damage beds of bottom-living mollusks in the Gulf of Mexico or elsewhere have resulted from confusing them with the Eagle Rays. The primary function of the cephalic fins is to direct the planktonic food to the mouth, for they have been described as moving these fins rapidly in front of the mouth as they swim. Also, it seems that the cephalic fins automatically close on anything that may touch the front of the head between them, and there are several records of a Manta becoming entangled in this way with the anchor line of a boat. For example, one taken in the Gulf of California held fast to the bow of the small boat from which

seeing a school of young Mantas only about two feet wide in Florida, but their small size suggests that they may have been the Lesser Devil Ray, *Mobula hypostoma*.

152. Norman and Fraser, Giant Fishes, 1937: 82.

153. Breder, Bull. Amer. Mus. nat. Hist., *94* (2), 1949: 89.

154. According to Coles (Bull. Amer. Mus. nat. Hist., *32*, 1916: 649), they never wholly clear the water. But Elliot (Carolina Sports, 1846: 85) reported seeing eleven leap "entirely out of the water" on one occasion near Beaufort, South Carolina. Many accounts have appeared subsequently of their doing so.

155. The 22-foot specimen referred to on p. 508 towed a 25-foot motor boat for more than ten miles, part of the time against the added resistance of an anchor dragging on bottom, and after five hours' resistance it was still alive, with four harpoons and several rifle bullets in its body (La Gorce, Nat. geogr. Mag., *35*, 1919: 483).

156. Elliott, Carolina Sports, 1846: 84, 85.

it had been harpooned until it was struck with a second iron.[157] It has even been reported that a shoal of Mantas entangled themselves in this way among the posts of a fence running out into the water.[158] Accounts of their towing boats which they have fouled in this way doubtless have some foundation, though probably exaggerated.

Mantas are sometimes encountered offshore over deep water, as in the Caribbean, in the Gulf Stream off Cuba, in the Gulf of Mexico, and around Bermuda. But they are seen more often in shoal water within a few miles of land. For example, schools of them have been reported along the borders of muddy water where the Mississippi flows into the Gulf of Mexico. They are often seen along the Southwest Florida Coast, and they were described many years ago as entering shallow inlets on the South Carolina Coast at high tide, returning to the sea again on the ebb.

Presumably Mantas are year-round residents in the tropical part of their range and northward to southern Florida. However, northward from Florida, on the Atlantic Coast of the United States, they are known only as warm-season visitors, having been reported in South Carolina waters in May, June, July, and August;[159] off North Carolina in July; off Delaware Bay and New Jersey in late August and early September; and off Block Island and on Georges Bank in August. A pair has been seen in the act of mating, but the details of the event were not observed.[160]

They are often accompanied by remoras (*Echeneis*, *Remora*) that cling to the anterior parts of their pectorals or inside their mouths.

Numerical Abundance. Perhaps Mantas are as numerous in the Gulf of Mexico off the mouth of the Mississippi and in the shallow waters along southwestern Florida as they are anywhere in the Atlantic. But no record seems to have been kept of the numbers sighted there or elsewhere over any considerable period. In estimating their abundance from published reports, one must bear in mind that characterizations of so large an animal as "common" or "abundant" may rest on only a few individuals. Thus, a recent statement that they "abound" in Beaufort Harbor, North Carolina, appears to have been based on the harpooning of 16 there in the summer of 1843.[161]

Relation to Man. Mantas, if not too large, are sometimes exposed for sale in tropical American ports.[162] The liver also yields oil and the skin has been used as an abrasive. They are (or have been) harpooned for shark bait in the Gulf of California.[163] But they are not taken in large enough numbers to be of any commercial importance anywhere.

They are harpooned from time to time by sport fishermen.[164] They put up a prolonged resistance, sometimes towing the boat for several hours before they are exhausted

157. Vaillant and Diguet (Bull. Mus. Hist. nat. Paris, *4*, 1898: 127). A more recent instance is the capture of the 21-foot New Jersey specimen (mentioned on p. 502) after it had entangled itself with the anchor and anchor rope of a fishing boat lying five miles offshore.

158. Elliott, Carolina Sports, 1846: 16.

159. Knowledge of the occurrence of Mantas along South Carolina is due chiefly to Elliott's accounts (Carolina Sports, 1846, 1859) of his experiences with them in the region of Port Royal Sound more than a century ago.

160. Elliott, Carolina Sports, 1859: 93–94.

161. Gudger, Science, N. S. *55*, 1922: 339.

162. Beebe and Tee-Van (Zoologica N. Y., *10*, 1928: 32) saw one six feet wide in the market in Port-au-Prince, Haiti.

163. Vaillant and Diguet, Bull. Mus. Hist. nat. Paris, *4*, 1898: 128.

164. Many accounts of Devil-fishing have appeared; see especially Elliott (Carolina Sports, 1846: 68–72); Holder (Big Game at Sea, 1908: chap. 1); and La Gorce (Nat. geogr. Mag., *35*, 1919: 483–488).

or diving to the bottom to resist by sheer weight.[165] Despite their great size, Mantas are wholly inoffensive unless attacked. One might damage or capsize a boat in its struggles to escape or might accidentally grasp between its cephalic fins a fisherman unlucky enough to fall overboard directly in front of it. The old tale that they devour pearl divers, having first clasped them between the cephalic fins or enveloped them with the pectorals, is without foundation.

Range. It will not be possible to define the geographic range of *Manta birostris* until we know the specific relationship between *Manta* of the Atlantic and the representatives of the genus in other oceans (see discussion, p. 502). If *M. birostris* is identical with these, its range corresponds to that of the genus *Manta*, as stated on p. 501. However, if the Atlantic form is distinct from those of the Indo-Pacific, the range of the species *M. birostris*, as now known, would include the western side of the Atlantic from middle Brazil to the Carolinas, accidentally to southern New England and Georges Bank, and seaward to Bermuda; Madeira; and tropical West Africa, whence a specimen has been reported recently, its identity evident from a photograph that shows clearly the terminal position of the mouth.[166]

Occurrence in the Western Atlantic. Sightings or captures of this large Ray have attracted less attention in the public press, in sportsman's periodicals, and in scientific literature than might have been expected, perhaps because it is pursued by so few persons and because it is so large that few specimens are to be found in the collections of museums. It has been reported reliably from: Rio de Janeiro, Brazil; French Guiana,[167] British Guiana, Venezuela;[168] Trinidad, the Grenadines, Barbados, Haiti, Jamaica, and the Caribbean in general; the north coast of Cuba[169] and the Gulf Stream; the Bahamas; various localities along the west and east coasts of Florida; the Gulf of Mexico, including the northern side off the mouth of the Mississippi; Savannah, Georgia; and Bermuda. At intervals it visits the coastal waters of South Carolina in numbers, as in the forties and fifties of the last century, when a number of them were harpooned in Charleston Harbor, and near Beaufort, South Carolina.[170] But this appears to have represented an unusual dispersal of Mantas northward, for we are informed[171] that it is now many years since one has been seen in these waters, though watch has been kept for them there. The few records of it farther to the northward are not only spread over a long period of time but are based on odd specimens only: off Cape Lookout and off Charlotte Harbor, North Carolina;[172] off the mouth of Delaware Bay;[173] off New Jersey;[174] near

165. Norman and Fraser, Giant Fishes, 1937: 83.
166. Anon. (Notes Afric., *37*, 1948: pl. not numbered). The specimen, when lying on the beach, appears to have been 12–14 feet wide by comparison with the height of men standing beside it.
167. Gallus, Tableau Cayenne Guiane Franc., 1792: 132 (not seen).
168. Gosse, The Ocean, 1846: 193–194; Röhl, Fauna Descript. Venezuela, 1942: 310.
169. Luis Howell-Rivero informs us that it is "commonly harpooned around Cuba and from Jamaica."
170. Elliott, Carolina Sports, 1846, 1859; Holmes, Proc. Elliott Soc. nat. Hist., 1, 1859: 39.
171. By E. Milby Burton, Director of the Charleston Museum, South Carolina.
172. It is probable that early reports of *Manta* from North Carolina were based chiefly on the Lesser Devil Ray, *Mobula*.
173. One in 1822 (Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 118) and a second in 1823 (Mitchill, Ann. New York Lyc., *1*, 1824: 23).
174. Two specimens (Fowler, Science, N. S. 17, 1903: 594) and our Study Material, p. 502.

New York;[175] a few miles off Block Island at the entrance to Long Island Sound;[176] and on the southeast part of Georges Bank, where a pair of Mantas, judged to be 18–19 feet wide, were encountered late in August 1949, so close at hand that their cephalic fins and purplish color were noted.[177]

Synonyms and Western Atlantic References:

Devil Fish[178] Catesby, Nat. Hist. Carolina, *1*, 1731: XXXII (capture, Carolina); Elliott, Carolina Sports, 1846: 16–94; also 1859 (capture, nos., S. Carolina); Gill, Smithson. misc. Coll., 52, 1909: 161 (ills.).

Raja birostris, rostro bifido, Walbaum, P. Artedi Genera Pisc. Emend. Ichthyol., 3, 1792: 535 (diagn. by ref. to: the Diabolus marinus of Willughby [Hist. Pisc., Append., 1686: 5, pl. 9, fig. 3] no local.; the Devil Fish of Catesby [Nat. Hist. Carolina, *1*, 1731: XXXII] Carolina; and the Divel Fish of Pennant [Arctic Zool., Suppl., 1787: 104] no local. [probably a *Mobula*].

Raja birostris Donndorff, Zool. Beitr., *3*, 1798: 876 (diagn. by ref. to Walbaum, 1792).[179]

Cephaloptera giorna Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 115, pl. 6 (descr., color, size, embryo, off Delaware Bay and Savannah, Georgia).

Cephalopterus vampyrus Mitchill, Ann. New York Lyc., 1, 1824: 23, pl. 2, fig. 1 (descr., size, off Delaware Bay); Oken, Isis, Heft 10, 1832: 1063, pl. 28, fig. 4 (same spec. as in Mitchill, 1824); Bridge, Cambr. Nat. Hist., *7*, 1904: 466 (size, W. Indies).

Cephalopterus manta Bancroft, Zool. J., *4*, 1829: 453 (descr., meas., color, habits, Jamaica).

Manta americana Bancroft, Zool. J., *4*, 1829: 454 (to replace *Cephalopterus manta* Bancroft).

Ceratoptera lesueurii Swainson, Nat. Hist. Fish. Amphib. Rept., *2*, 1839: 320 (diagn., ill., N. Amer.).

Ceratoptera johnii Müller and Henle, Plagiost., 1841: 186, 198, pl. 59 (descr., meas., embryo, Jamaica).

Cephaloptera vampirus DeKay, Zool. N. Y., *4*, 1842: 377, pl. 67, fig. 219 (descr. after Lesueur, 1824 and Mitchill, 1824).

Cephaloptera diabolus Valenciennes, in Cuvier, Règne Anim., Poiss., Atlas, 1839–1843: pl. 119 (ills., N. Amer.).[180]

Cephaloptera, no specific name, Gosse, The Ocean, 1845: 174; 1856: 210 (capture, size, La Guayra, Venezuela).

Brachioptilon hamiltoni Newman, Zoologist, *7*, 1849: 2396 (Gulf of Mexico).

Cephaloptera elliotti Holmes, Charleston [S. Carolina] Mercury, June 24, 1854 (S. Carolina; not seen).

Diabolicthys elliotti Holmes, Proc. Elliott Soc. nat. Hist., *1*, 1859: 43, pl. 3 (color, teeth, tail, swimming, nos., capture, refs., S. Carolina).

Ceratoptera vampirus Duméril, Hist. Nat. Poiss., *1*, 1865: 660 (descr., New York specimen from Milbert); Yarrow, Proc. Acad. nat. Sci. Philad., *29*, 1877: 216 (listed, near Beaufort, N. Carolina).

Ceratoptera vampyrus Günther, Cat. Fish. Brit. Mus., *8*, 1870: 498 (descr., refs., embryo, Jamaica, same specimen as in Müller and Henle, 1841); Uhler and Lugger, Rep. Comm. Fish. Md., 1st ed., 1876: 185; 2nd ed., 1876: 157 (listed, near entrance to Chesapeake Bay).

Ceratoptera birostris Goode, Proc. U. S. nat. Mus., *2*, 1879: 120 (listed, E. coast Florida); Goode and Bean, Proc. U. S. nat. Mus., *2*, 1879: 155 (listed, off Pensacola, Florida); Proc. U. S. nat. Mus., *5*, 1882: 240 (listed, Gulf of Mexico).

Manta birostris Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 52 (descr., trop. Amer. to N. Carolina in Atlant. and to San Diego, Calif. in Pacif.); True, List Vert. Anim. S. Carolina, in Handb. S. Carolina, 1883: 160 (listed, S. Carolina); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, W. Indies, also trop. Pacif.); Henshall, Bull. U. S. Fish Comm., *9*, 1891: 384 (listed, Florida); Lönnberg, Oefvers.

175. Duméril, Hist. Nat. Poiss., *1*, 1865: 661.

176. Gudger (Science, N. S. *55*, 1922: 339). *Manta* has been reported near the entrance to Chesapeake Bay also (Uhler and Lugger, Rep. Comm. Fish. Md., ed. 1, 1876: 185; ed. 2, 1876: 157) but without supporting evidence.

177. Reported by Captain Henry W. Klimm while out after swordfish.

178. Anglers have referred to *Manta* as Devil Fish in many accounts of experiences with them. The citations included here were selected because they contain especially valuable information.

179. Whitley (Aust. Zool., *8*, 1936: 180) has pointed out that the species is to be credited to Donndorff, 1798 because the name as used by Walbaum, 1792 was not binomial.

180. The dates at which the individual plates appeared is not definitely known; see Sherborn (Ann. Mag. nat. Hist., [9] *10*, 1922: 555, 556) and Whitley (Aust. Zool., *8*, 1936: 179).

Svensk. Vet. Akad. Forh., 51, 1894: 112 (listed, W. Florida); Cory, Hunting Fishing in Fla., 1896: 106 (capture, W. Florida); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 92 (descr., refs., trop. Amer., Florida); Rep. U. S. Comm. Fish. (1895), 1896: 225 (listed, trop. Amer. to New Jersey; also Pacif.); Evermann and Kendall, Rep. U. S. Comm. Fish. (1899), 1900: 50 (listed, W. Florida locals.); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (4), 1900: pl. 18, fig. 39 (ill.); Wilson, Amer. Nat., *34*, 1900: 355 (listed, C. Lookout, N. Carolina); Fowler, Proc. Acad. nat. Sci. Philad., *55*, 1903: 332, footnote (specific name); Gill, Forest and Stream, *60* (22), 1903: 431 (name); Schreiner and Ribeiro, Arch. Mus. nac. Rio de J., *12*, 1903: 82 (listed, Copacabana, near Rio de Janeiro, Brazil; spelled *birrostris*); Hargreaves, Fish. Brit. Guiana, 1904: 17 (listed, Brit. Guiana, but ill. p. 18 appears to be *Mobula*); Jordan, Guide to Study Fish., *1*, 1905: 560 (genl.); Jordan and Thompson, Bull. U. S. Bur. Fish., *24*, 1905: 232 (listed, Tortugas, Florida); Fowler, Rep. N. J. Mus. (1905), 1906: 80, pl. 5 (descr. after Lesueur, 1824, ill. after Jordan and Evermann, 1900; off Stone Harbor, New Jersey); Smith, N. C. geol. econ. Surv., *2*, 1907: 47 (diagn., ill. after Jordan and Evermann, 1900; N. Carolina, but perhaps confused with *Mobula hypostoma*); Anon., Bull. N. Y. zool. Soc., 29, 1908: 420 (size, weight); Vincent, Sea Fish. Trinidad, 1910: 53, 90 (size, nos., photo, Trinidad); Fowler, Proc. Acad. nat. Sci. Philad., *63*, 1911: 5 (listed, off Delaware Bay by old refs.); Bean, Proc. biol. Soc. Wash., *25*, 1912: 121 (listed, Bermuda); Gudger, Proc. biol. Soc. Wash., *25*, 1912: 152 (C. Lookout, N. Carolina); Engelhardt, Abh. bayer. Akad. Wiss., Suppl. *4* (3), 1913: 104 (range); Garman, Mem. Harv. Mus. comp. Zool., *36*, 1913: 454 (refs., descr.); Coles, Proc. biol. Soc. Wash., *28*, 1915: 94 (seen, C. Lookout, N. Carolina); Amer. Mus. J., *16*, 1916: 217 (size, capture, photos, W. Florida); Bull. Amer. Mus. nat. Hist., *35*, 1916: 649 (dermal armature, color, habits, photos, capture, N. Carolina and W. Florida); Radcliffe, Bull. U. S. Bur. Fish., *34*, 1916: 280 (descr. teeth, dermal armature, early rep. from N. Carolina probably *Mobula*); Townsend, Bull. N. Y. zool. Soc., *22* (6), 1919: 140 (listed, Caribbean, nos., Florida, Bimini, Bahamas, specimen 22 ft. wide); Fowler, Proc. biol. Soc. Wash., *33*, 1920: 146 (listed, New Jersey by ref. to Mitchill, 1824 and Lesueur, 1824); Gudger, Nat. Hist. N. Y., *22*, 1922: 243 (photo), 246 (with remoras); Science, N. S. *55*, 1922: 338 (size, weight, off Block Island); Meek and Hildebrand, Field Mus. Publ. Zool., *15* (1), 1923: 94 (refs., diagn.); Nichols and Breder, Zoologica N. Y., *9*, 1927: 29 (ref. to Block Island specimen); Hildebrand and Schroeder, Bull. U. S. Bur. Fish., *43*, 1928: 71 (descr. after Garman, 1913); Beebe and Tee-Van, Zoologica N. Y., *10*, 1928: 32 (size, Haiti); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 39 (genl.); Jordan, Manual Vert. Anim. NE U. S., 1929: 20 (diagn.); Truitt, Bean and Fowler, Bull. Md. Conserv. Dp., 3, 1929: 33 (diagn., listed, off Maryland); Fowler, Fish Culturist, *9* (8), 1930: 115 (listed, off Delaware Bay by old refs.); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), 2, 1930: 32 (listed, trop. Amer.); Gowanloch, Bull. La. Conserv. Dep., 21, 1932: 86, 87 (ill., nos., off Mississippi R.); Beebe and Tee-Van, Field Bk. Shore Fish. Bermuda, 1933: 31 (listed, Bermuda); Gowanloch, Bull. La. Conserv. Dep., 23, 1933: 241 (capture, size, W. Florida, nos. off Louisiana); Beebe and Hollister, Zoologica N. Y., *19* (6), 1935: 209 (listed, Grenadines, W. Indies); Whitley, Aust. Zool., 8, 1936: 179 (refs.); Norman and Fraser, Giant Fishes, 1937: 81 (genl.); Beebe and Tee-Van, Zoologica N. Y., 26 (3), 1941: 276 (color, cf. Pacif. *M. hamiltoni*); Fowler, Fish Culturist, *21* (9), 1942: 66 (color, size, Cuba); Röhl, Fauna Descript. Venezuela, 1942: 370 (Venezuela; not seen); Fowler, Monogr. Acad. nat. Sci. Philad., 7, 1945: 100 (listed, N. Carolina); Anon., Notes Afr., Inst. Franç. Afr. Noire, Dakar, 37, 1948: pl. not numbered (photo, specimen on beach, trop. W. Africa, ident. verified by position of mouth); Breder, Bull. Amer. Mus. nat. Hist., *94* (2), 1949: 89 (use of cephalic fins in swimming, diurnal color change, Bimini, Bahamas); Maul, Lista Sist. Peixes Madeira, 1949: 140 (listed, Madeira); Schultz, Proc. U. S. nat. Mus., *94*, 1949: 32 (listed, Venezuela).

Manta manatia Fowler, Science, N. S. *17*, 1903: 594 (listed, off Stone Harbor, New Jersey).

Manta ehrenbergii Ribeiro, Arch. Mus. nac. Rio de J., *14*, 1907: 195, 212 (descr., refs., vicinity of Rio de Janeiro); Fauna brasil., Peixes, *2* (1) Fasc. 1, 1923: 50 (same specimen as in Ribeiro, 1907).

Sea bat, Holder, Big Game at Sea, 1908: 1–35, pl. facing p. 24 (capture, photo showing white markings).

Manta birostra Holder, Big Game at Sea, 1908: 17 (capture, Florida locals.).

Manta vampyrus Gill, Smithson. misc. Coll., *52*, 1909: 176 (teeth, nos., S. Carolina, range).

Doubtful Synonyms:

Raja fimbriata Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *4*, [An. X] 1801–1802: 677, pl. 16,

fig. 3 (based on obviously inaccurate drawing, as likely to be *Mobula* as *Manta*; mid-Atlantic, Lat. 38°58′ N, Long. 42°10′ [W] from meridian of Paris).

Caphaloptera giorna Anon., R. Coll. Surg., Descr. Ill. Cat. Mus., *2*, 1834: 38; *3*, 1836: 148 (anat.; doubtful whether *Mobula* or *Manta*).

Cephaloptera manta Anon., R. Coll. Surg., Descr. Ill. Cat. Mus., *2*, 1834: 84; *4*, 1838: 51 (anat., doubtful whether *Mobula* or *Manta*).

Probably not *Brachioptilon hamiltoni* Newman, Zoologist, *7*, 1849: 2358 (Gulf of California).

Probably not *Ceratoptera ehrenbergii* Müller and Henle, Plagiost., 1841: 187 (Red Sea).

Not *Raja giorna* Lacépède, Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., *5*, 1802–1803: 662, 666, pl. 20, fig. 3; equals *Raia mobular* Bonnaterre 1788.

Not *Raja manatia* Bloch and Schneider, Syst. Ichthyol., 1801: 364, which was a *Mobula*; see p. 497.

Not *Raia cornuta* Lesueur, J. Acad. nat. Sci. Philad., *4*, 1824: 120 (Azores; included in synonymy of *Manta birostris* by Whitley [Aust. Zool., *8*, 1936: 179] but based on Raie cornue, Lacépède [Hist. Nat. Poiss., 4° ed., in Buffon, Hist. Nat., 1, 1798: 151, footnote]; equals *Mobula mobular* [Bonnaterre] 1788).

CHAPTER TWO

Chimaeroids[1]

BY

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GENERAL DISCUSSION

The scope of this chapter, the sources of material, the method of measuring, and the bases for the discussions of habits and geographical distribution have been the same generally as for the chapter on the batoid fishes (p. 1). The illustrations are by E. N. Fischer.

Subclass HOLOCEPHALI

Characters. Cartilaginous fishes (Chondrichthyes) with a single external gill opening on either side covered over by an opercular fold of skin with cartilaginous supports and leading to a common branchial chamber into which the true gill clefts open; five gill arches, four pairs of gill clefts, and four pairs of gills; upper jaw (palatoquadrate cartilage) fused throughout its length to lower surface of cranium, without visible trace of demarkation between the two; the two branches of lower jaw (Meckel's cartilages) fused together in front and suspended behind only from a prominence from rear end of upper jaw cartilage; no connection between lower jaw and hyoid arch; no distinct hyomandibular cartilage,[2] though it is perhaps represented by a small cartilage connected above with the hyoid; three rostral cartilages articulated to front of cranium; cranium with a horizontal transverse septum dorsal to anterior part of brain case; auditory capsule with incomplete inner (median) wall; no distinct vertebral centra; notochord not constricted segmentally but surrounded in most by numerous calcified rings; the two halves of the pelvic girdle united below by a ligament only; teeth represented by two pairs of dental

1. Contribution No. 571 from the Woods Hole Oceanographic Institution.
2. There is such a hyomandibular cartilage with which the lower jaw is connected in all elasmobranchs except for the notidanoid sharks (Notidanoidea).

plates in upper jaw and by one pair in lower jaw; no cloaca; urinary papilla and genital apertures posterior to anus;[3] a pair of abdominal pores near anus, putting peritoneal cavity into communication with exterior (as in sharks), but these are more or less obliterated during growth; males with an intromittent organ (clasper), simple or divided, developed from base of each pelvic fin on inner side; a supplemental clasping organ or prepelvic tenaculum close in front of each pelvic fin; also a frontal clasper on forehead, a structure unique among fishes; scales, when present, essentially similar to those of elasmobranchs.

Orders. The few modern chimaeroids resemble one another so closely in their bodily make-up that they are grouped here in a single order, Chimaerae.[4]

Relationship to Other Vertebrates. "The living chimaeroids are a divergent and modified branch of some primitive shark-like type. Beside certain characters of the bony fishes, they have acquired others distinctively their own. Their relationship to the elasmobranchs is seen in their cartilaginous skeletons, dermal denticles, the brain structure, and especially the reproductive organs. The large eggs and their enclosure in horny coverings is another interesting feature in common. The single gill opening is modified toward the bony fish type,"[5] as is the presence of a dermal opercle covering the gill opening as well as the fact that the anus opens externally in front of the urinogenital apertures rather than into a cloaca.

Order CHIMAERAE[6]

External Characters. Trunk, in all modern chimaeroids, more or less compressed laterally, tapering rearward to slender tail. Snout either rounded-conical, extended as a long pointed beak, or bearing a curious hoe-shaped proboscis. Two dorsal fins; first dorsal triangular, usually higher than second and perhaps incompletely separated from latter in some cases, edged anteriorly by a strong sharp-pointed bony spine[7] reaching nearly to apex of fin or a little beyond; both spine and first dorsal capable of erection and of depression into a groove in midline of back; second dorsal extending back nearly to origin of caudal fin, either of uniform height throughout its length or partially or wholly subdivided, not erectile or depressible. Caudal fin narrow, tapering, prolonged in some as a long filament, either with a more or less definite lower anterior lobe and with its axis somewhat raised (i. e., shark-like or heterocercal) or without lower anterior

3. See Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: pl. 1, fig. 2) for illustration showing relative positions of anus and urinary papilla in *Hydrolagus colliei.*
4. In this we follow Jordan (Class. Fish., 1923: 105, Chimaeroidei), Goodrich (in Lankester, Treat. Zool., 9, 1909: 168, Holocephali), Romer (Vert. Paleont., 1945: 578, Chimaerae), Berg (Class. Fish., Engl. Trans., 1947: 383, Chimaeriformes), and various earlier authors. The chimaeroids have recently been distributed by Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 487) between two orders, Chimaeroidei without proboscis, the males with bifid or trifid claspers, and Callorhinchoidei with proboscis, the males with simple rod-like claspers. But this division takes no account of the nature of the caudal fin, i. e., whether heterocercal or diphycercal, which seems to us more significant from the evolutionary standpoint than either the nature of the snout or the secondary sexual characters.
5. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 486.
6. This name seems to have been employed first in an inclusive sense by Thienemann (Lehrb. Zool., 1828: 412).
7. The dorsal spine evidently represents a modified dermal denticle.

lobe and with its axis continuing on the general longitudinal axis of the trunk (diphycercal). A short separate anal fin marked off from caudal by a deep notch in some. Pectoral and pelvic fins well developed, the latter situated about on a level with anus, far rearward. Bases of fins thick and fleshy, their outer parts thin and flexible.

Eyes large, on sides of head, encircled by a narrow free lid that is not movable; orbits tending to come together above. Spiracle absent after birth but temporarily represented during embryonic development. Nostrils large, close in front of mouth, each connected with outer corner of mouth by a deep groove roofed over by lateral lobe of upper lip, thus forming a closed channel through which water is drawn into mouth in breathing; nasal aperture incompletely subdivided by a complex dermal fold, projecting inward from outer side of nostril and supported by a cartilage. Mouth on lower surface of head, a little in front of level of front of eyes, transverse, small. Lips thick and fleshy and supported by complex cartilages; upper lip of three parts, a transverse median lobe and a large lateral lobe on either side separated from the median part of the lip by a groove connecting mouth with nostril. Roof of mouth without transverse curtain or breathing valve; floor of mouth with a short and fleshy wedge-shaped tongue,[8] free at tip, reaching forward between posterior parts of mandibular dental plates from close in front of first internal gill cleft. External gill openings low down on sides, close in front of origins of pectoral fins. Anus close in front of origin of pelvic fins, the urogenital openings close behind.

Dental plates persistent, the base growing constantly;[9] basal part smooth, of vasodentine with more or less conspicuous ridges or prominences (known as tritors) covered with vitrodentine; two pairs, an anterior vomerine and a posterior (usually the larger) palatine on roof of mouth; one mandibular pair on floor of mouth. Inner posterior edges of palatines and of mandibulars more or less concealed by expansions of fleshy tissues of roof and floor of mouth.

Skin more or less roughened along midline of back by small denticles in some species, also here and there along mucous canal system[10] and on claspers and tenacula of males; otherwise naked and slippery with mucus.

Sensory mucous canal system well developed, especially on head, much more noticeable than in other cartilaginous fishes. Lateral canal continuous from below eye rearward onto axis of caudal, a closed canal in some but an open groove in most, its wall supported by numerous crescent-shaped limy bars supposed to represent modified dermal denticles; mucous canals on head partially closed, and marked by series of large pores; each side of head with a cranial canal running forward above eyes out onto snout, the two connected across nape in front of dorsal spine by an aural canal; cranial canal continuing downward from its junction with aural canal as the occipital canal to junction with lateral canal, then turning forward below eye to snout, giving off first a jugular branch to region of gill opening, then either an oral branch and an angular branch

8. Sharks also have a distinct tongue, but Skates and Rays do not.
9. They do not show any sign in their embryonic development of being formed by the fusion of separate teeth or denticles, but they are usually regarded as homologous with the teeth of elasmobranchs.
10. In some fossil chimaeroids the skin was covered with strong denticles while others had plates on the head.

separately to mouth region and to lower surface of snout or a joint trunk bifurcating into a corresponding oral branch and an angular branch. Jugular and oral canals ending blind, but cranials, orbitals and angulars of the two sides joining to form a complex closed pattern on lower anterior surface of snout.[11]

Claspers of males arising from axils of pelvic fins, free for their entire length; more or less roughened with small denticles either along entire clasper or only at tips;[12] simple rods in some, bifid in others, or with one of the branches again subdivided (trifid) in still others. Prepelvic tenacula short, blade-like, either serrate along anterior margin or armed with denticles on sides, each normally retracted into a dermal pocket close in front of the respective pelvic fin but protruded during sexual activity. Females of some, as well as males, with prepelvic pockets but no tenacula (p. 558). Frontal tenaculum short, curved, club-shaped, with more or less swollen tip, armed anteriorly with stout thorn-like denticles on lower side; carried pressed downward and forward into a groove on forehead normally but raised during mating.

In color the chimaeroids vary from silvery (variously marked with stripes or spots) to uniform leaden or almost black, a range of coloration correlated, it seems, with the depths at which they live. Some are described as faintly luminous,[13] but no luminescent organs have been found on any.

Internal Characters. The following internal characters, supplemental to those by which the subclass is defined (p. 516), are of interest. Stomach less differentiated than in elasmobranchs; intestine straight, the spiral valve of only 3–3 1/2 turns. Heart closely resembling that of elasmobranchs; arterial cone with three rows of valves. Brain essentially shark-like; cerebral hemispheres large, each extending forward as a slender tube, the so-called olfactory peduncle with olfactory bulb at extremity; diencephalon trough-shaped, thin walled, and so long that hemispheres are separated from optic lobes (further in some than in others); medulla expanded on either side as a frilled—so-called restiform—body; optic nerves forming a chiasma. Kidney shorter and stouter than in Sharks, much longer in males than in females.[14] Gill folds[15] attached to interbranchial septa nearly to their tips, much as in elasmobranchs, but septa ending outwardly about even with tips of gill folds instead of extending outward to join skin on sides of neck as in elasmobranchs. The four internal gill clefts closely crowded together, each cleft bearing a gill on both anterior and posterior face;[16] second to fourth gill arches each with a double series of low transverse folds around inner margin; fifth gill arch with one such series on anterior side; hyoid arch lacking these folds. Dermal

11. Nomenclature of the mucous canals according to Garman (Bull. Mus. comp. Zool. Harv., *17*, 1888: pls. 1, 2, 4).
12. The denticles in Holocephali are homologous with the placoid scales of elasmobranchs, both embryologically and structurally, the outer layer consisting of vitrodentine. For further account of them, see especially Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 114–116).
13. Whitley, Fish. Aust., *1*, 1940: 233.
14. For a brief general account of the anatomy of the chimaeroids, see especially Parker and Haswell (Textb. Zool., *2*, 1940: 222).
15. Usually called "filaments," but this is a misnomer since this term implies a string- or thread-like structure, whereas the gills actually are in the form of lamellae.
16. Thus there is a posthyomandibular hemibranch, three holobranchs, and an anterior hemibranch on the fourth gill arch, on each side.

operculum supported by a fan of slender cartilaginous rods, some fused basally to form a thin disc connected with ceratohyal cartilage, others borne directly on latter. Cartilaginous support for first dorsal fin a vertical plate to which dorsal spine is firmly attached; this plate articulated with a projection from upper side of vertebral column.[17] Second dorsal fin supported basally by a series of numerous short rod-like radial cartilages edged outwardly by a longitudinal ligament. Basal parts of pectoral fins supported by a fan of numerous cartilaginous rods, divided transversely into several series (allowing for motion) and borne basally by a cartilaginous element corresponding to the metapterygial cartilage of elasmobranchs; also two other basal cartilages seemingly corresponding to elasmobranch propterygial and mesopterygial cartilages, but these not bearing radials among chimaeroids. Cartilaginous skeleton of pelvic fins similar to that of pectorals, but only one basal cartilage, and radials shorter, with only one transverse articulation. Anal and caudal fins without radial cartilages, supported by double series of slender horny rays, as are outer parts of dorsal, pectoral and pelvic fins. Pectoral girdle not joined above to vertebral column but attached to dorsal musculature[18] by a slender suprascapular cartilage on either side. The two halves of pelvic girdle united below in midline by a ligament only, each end prolonged beyond point of articulation of pelvic fin as a so-called "iliac" process running upward so that pelvis (like pectoral arch) is suspended above from dorsolateral musculature of trunk without direct connection with vertebral column. Transverse (pubic) portion of each half of pelvis pierced by an aperture covered over by membrane, or pierced by two apertures in some. The three rostral cartilages rod-like, one articulated to front of cranium above, the two others articulated lower down to nasal capsules. (In such Sharks as have three rostral cartilages, the unpaired one is lowermost, the pair uppermost.) Cranium much compacted, the anterior portion greatly compressed sidewise in most, with a relative increase in vertical height as compared with elasmobranch cranium. No anterior fontanelle, the space between and behind olfactory capsules bridged over by cartilage. The orbits lie above the level of the brain case in some, in which case the two orbits are separated one from the other by a vertical membranous partition only;[19] in others the orbits are on a level with the brain case from which each is separated by a membrane alone.[20] Posterior part of brain cavity high, anterior part low, tunnel-like, separated above by a horizontal partition of cartilage from a similar cavity containing branches of the trigeminal (5th) nerve. Auditory capsules not separated from brain cavity; greater part of membranous labyrinth of inner ear lodged in pits in lateral walls of cranium, separated from brain cavity by membranes only. Posterior face of cranium articulated to vertebral column by a saddle-shaped condyle, concave from front to rear but convex dorsoventrally, with an additional flat condyle surface above it on either side. Most anterior vertebral segments (dozen or so) fused together under first dorsal fin into a continuous tube, its segmental

17. The first dorsal fin has two or three basal cartilages in some fossil chimaeroids.
18. The chimaeroids resemble the Sharks in this respect and differ correspondingly from the Skates and Rays in which the pectoral girdle is attached above to the vertebral column.
19. Chimaeridae and Rhinochimaeridae.
20. Callorhinchidae.

nature proven by openings through which spinal nerves emerge.[21] Midanterior part of vertebral column bearing neural arches with processes as well as haemal arches, these dwindling away toward head, and also rearward from level of pelvic girdle.

Axial skeleton of clasper articulated to inner edge of basal cartilage of pelvic fin; two short basal cartilages (the first with a small cartilaginous element on inner side) and a long slender terminal cartilage, either simple or with two slender rods articulated to its basal part in those in which clasper is branched. Prepelvic tenaculum supported by a single short blade-shaped cartilage, or by two (thought to represent a modification of anterior edge of pelvic fin), articulated to pubic part of pelvis. Frontal tenaculum supported by a short club-shaped cartilage, articulated to front of cranium, above and in front of orbits; its tip armed with sharp recurved thorns.

Size. The chimaeroids range in length from about 600 to 2,000 mm at maturity (24 to 79 in.), with females rather larger and stouter in form than males.[22]

Development. Fertilization is internal and is effected by the pelvic claspers, as it is among all modern elasmobranchs. The act of pairing has not been observed. "By indirect evidence, however, the mode of copulation appears to be distinctly shark-like. The accessory claspers, i. e., the male's frontal spine and anterior appendage of the pelvic fin are evidently of use in securing the female."[23] All of the chimaeroids are oviparous, depositing eggs that are astonishingly large for the size of the parent fish. They are enclosed in brown horny capsules that are elliptical, spindle-shaped, or tadpole-shaped, often with wide lateral longitudinal flanges or narrower median-longitudinal keels, and are of curious and characteristic shapes, suggesting in their appearance the fronds of some large brown alga.[24] It is not known whether the embryo case has openings when first laid. But soon either one pair of longitudinal slits or 45–200 pairs of pores open along the margin of its posterior extension in the angles with the lateral flanges. Also, a pair of so-called opercular slits open along the edges of its anterior prolongation; these slits are on the side opposite to the posterior slits or opposite to the pores (if these are confined to one side only), their edges either separate or interlocking so as to form a sort of grating, allowing water to enter. It is by fracturing the shell crosswise, between the anterior ends of these opercular slits, that the embryo escapes from the egg capsule.

The union of the male and female sex cells takes place in the uppermost portion of the oviduct, and the egg is in an early stage of cleavage when it is laid. Two eggs are laid simultaneously, one from each oviduct, and a pair of capsules is often carried by a female for some hours, or perhaps for days, each protruding for the greater part of its length. But the actual process of deposition did not take more than ten minutes in one

21. The anterior part of the vertebral column shows more obvious signs of segmentation in some of the fossil chimaeroids.

22. According to Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 13), females are about $^1/_{12}$ longer and $^1/_7$ heavier than males.

23. Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 23.

24. The following summary of development of chimaeroids is based on Dean's (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 48–114) account of the Californian *Hydrolagus colliei* and on other available sources. We have no first-hand observation to contribute.

case that came under observation in an aquarium.[25] It has been observed repeatedly that the external openings of the oviducts are much swollen after an egg has been deposited, as is the anal region in general with the margins of the pelvic fins. It has been suggested that the deposition of one pair of eggs may soon be followed by the fertilization and deposition of another pair, since maturing ova have been found in the ovary of females in which the openings of the oviducts were still swollen. It appears that the egg cases, when deposited, are either partly imbedded in the mud of the sea floor, whence they are sometimes brought up in a dredge or trawl, or are attached to stones, etc. Development in general resembles that of Sharks, the embryo temporarily having a cluster of slender external gill filaments on either side.[26] Only a small part of the yolk is enclosed in the embryonic yolk sac; the remainder breaks down to a creamy consistency, probably to be absorbed by the embryo through the external gill filaments so long as these persist and also to be taken in through the mouth. The period of incubation is between nine and twelve months[27] in species for which information is at hand. When the young hatch they already resemble their parents in all features that are diagnostic of the order to which they belong.

Habits. Chimaeroids, in breathing, take in water chiefly through the nostrils,[28] from which it passes through the grooves that connect the latter with the mouth (see p. 517), which is kept closed for the most part. Respiration in *Hydrolagus colliei* of the Pacific Coast of North America, the only species that seems to have been observed, may be as rapid as 100 per minute.[29]

Chimaeroids are feeble swimmers, propelling themselves chiefly by undulations of the posterior part of the body, second dorsal fin and caudal. The extensive pectorals are described as being constantly in motion dorsoventrally, with undulations running from the upper origin of the fin out around its rim.[30] They serve as both propelling and balancing organs. The pelvic fins are held horizontally and motionless most of the time, and the claspers in males are pressed together in the midline behind the fins. When motionless on the bottom, chimaeroids rest on the tips of the paired fins and on the tail, and females are supported on the postanal ventral pad also, if they have this curious structure (p. 523). They are more active by night than by day and are described as avoiding strong light, at least under aquarium conditions. They are delicate fish also; they struggle but little and soon die upon being taken out of water, nor do they make any use of the dorsal spine as a weapon. But they can bite more sharply than one might assume from the small size of the mouth.

Their diet includes whatever small invertebrates and small fishes are available locally, and those that occur in shoal water bite freely on almost any bait.

25. Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 26, footnote.
26. For illustrations of stages in embryonic development, see especially Schauinsland (Zoologica Leipzig, *16*, 1903: pls. 12–18 [*Callorhinchus*]); also Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906 [*Hydrolagus*]).
27. Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 27; Whitley, Fish. Aust., *1*, 1940: 237.
28. This is true of the Lungfishes (Dipnoi) also.
29. Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 18.
30. See Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 16–18) for an interesting eye-witness account of their activities.

Relation to Man. In the western side of the Atlantic, chimaeroids are caught so seldom that they are of no commercial importance. But their livers are rich in oil, which has been used to a small extent in Scandinavia from earliest times as a remedy, internal as well as external; it is also used somewhat on the Pacific Coast of Canada for cleaning guns,[31] and it is said to be an excellent general lubricant. In New Zealand, where chimaeroids are marketed for food, 360,000 pounds were landed in 1936–1938, which may serve as a representative year;[32] and they are common market fish on the coast of mid-China also.[33]

Depth and Geographic Range. The depth range of the group as a whole extends from close to the surface down to at about 1,400 fathoms, perhaps still deeper. Geographically, the range of one species or another is extensive also: eastern North Atlantic from Morocco, the Azores and the Mediterranean to Iceland and northern Norway, also inward to the Skagerrak; western North Atlantic from Cuba and the Gulf of Mexico to the Nova Scotian Banks; western South Atlantic from southern Brazil to Tierra del Fuego; Peru and Chile; eastern North Pacific from southern Alaska to southern California; Hawaiian Islands region; Japan and China; southern Australia (New South Wales, Victoria and Great Australian Bight); Tasmania; New Zealand; South Africa from Natal in the east around to Walfish Bay in the west.

Classification. The members of the order fall in three groups: A. with the front of the head simply rounded or conical; B. with a long pointed beak; or C. with a curious hoe-shaped proboscis (Fig. 127). Accordingly, three families are commonly recognized, Chimaeridae, Rhinochimaeridae and Callorhinchidae (see Key, p. 522).

Number of Genera and Species. Chimaeroids are one of the smaller major subdivisions of modern vertebrates; the number of known recognizable species totals only 24–28 at most, divisible into six genera.

Geological History. The modern genera *Chimaera* and *Callorhinchus* have been in existence since the Upper Cretaceous period. Other extinct representatives of the order Chimaerae are known from as far back as the Lower Jurassic. And another assemblage of fossil fishes, either classed as a separate order (Bradyodonti) of Holocephali,[34] or provisionally located there,[35] date back in geologic time to the Devonian.

Key to Modern Families

1 a. Snout with flexible hoe-shaped terminal appendage (Fig. 127); caudal fin with a distinct lower anterior lobe, its axis somewhat bent upward (tail heterocercal). Callorhinchidae, p. 558.

1 b. Snout rounded, conical or pointed, without hoe-shaped terminal appendage; caudal fin without distinct lower anterior lobe, its axis not bent upward (tail diphycercal).

31. Clemens and Willby, Bull. Fish. Res. Bd. Canada, *68*, 1946: 72.
32. Whitley, Fish. Aust., *1*, 1940: 237.
33. In Chekiang; see Fang and Wang (Contr. biol. Lab. Sci. Soc. China, *8*, 1932: 283).
34. Romer, Vert. Paleont., 1945: 578.
35. Berg, Class. Fish., Trav. Inst. Zool. Acad. Sci. URSS., *5* (2), 1940; Engl. Transl., 1947: 383.

2a. Snout short, rounded or conical (Figs. 119, 121); claspers of males bifid or trifid. Chimaeridae, p. 523.

2b. Snout long, pointed (Fig. 124); claspers of males simple, rod-like. Rhinochimaeridae, p. 548.

Family CHIMAERIDAE

Characters. Front of head rounded or conical, soft, without extended beak or hoe-shaped appendage. Lower surface of head with a conspicuous groove running around from one side to the other, close in front of nostrils. Second dorsal fin much longer than first, lower, and separated only a short distance from first by a low fold of skin without rays. Caudal fin narrow, tapering, with or without terminal filament; without distinct lower anterior lobe, its axis not bent upward (tail diphycercal). Anal fin distinct from caudal in some. Gums in upper jaw smooth, without transverse ridges. Dental plates more or less strongly ridged radially around their margins. Angular canal joining oral canal some distance out from point of union of resulting trunk with suborbital canal (Figs. 118, 120). Claspers of males either bifid or trifid; if bifid, each branch flat and somewhat spatulate, with thick skin, roughened by sharp recurved thorns; if trifid, the two main branches similar, the third branch more slender and rod-like, with thin smooth skin and somewhat swollen tip.[36] Prepelvic tenacula of male blade-like, concave, the cartilage covered over by thin skin, the inner border strongly serrate (Fig. 118E). External openings of prepelvic pouches transverse to longitudinal axis of body or oblique. Females without prepelvic pouches. Ventral surface on females posterior to genital openings with a longitudinal ridge or ventral pad, its lower side with a narrow groove extending from end to end; its function not known.

Vertebral column with many calcified rings surrounding notochord. Cranial orbits above level of brain case, separated one from the other only by a membranous partition. Cerebral hemispheres of brain separated from optic lobes, in contact with olfactory bulbs.

Genera. The 17 or so modern representatives of the family resemble one another so closely that all of them have been united in a single genus (*Chimaera* Linnaeus 1758) by two well known ichthyologists, either without further subdivision[37] or with four subgenera.[38] However, a clear-cut generic division can be drawn between those that have a separate anal fin and those that do not. Those with a separate anal fin are referred here to the genus *Chimaera* Linnaeus 1758, typified by *C. monstrosa* Linnaeus of the eastern North Atlantic. Those that lack a separate anal fin have been distributed variously by recent authors among three genera or subgenera,[39] depending on (a) whether

36. For accounts of the skeleton of the claspers, see especially Jungersen (Danish Ingolf Exped., *2* [2] No. 1, 1899: 69, pl. 1, fig. 14, pl. 6, figs. 69–71); for the soft parts, see especially Leigh-Sharpe (J. Morph., *36*, 1922: 201).
37. Garman, Mem. Harv. Mus. comp. Zool., *40* (3), 1911.
38. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 488–489.
39. *Hydrolagus* Gill 1862 (Proc. Acad. nat. Sci. Philad., 1862: 331); *Bathyopolex* Collett 1904 (Forh. VidenskSelsk. Krist., 9, 1904: 5); *Psychichthys* Fowler 1907 (Proc. Acad. nat. Sci. Philad., *59*, 1908: 419) and *Phasmichthys* Jordan and Hubbs (Mem. Carnegie Mus., *10*, 1925: 119).

the claspers are bifid or trifid, (b) whether the caudal filament is long or short, and (c) whether the upper margin of the second dorsal is nearly straight or is so deeply concave that the fin is partially or wholly subdivided. However, it is not possible to draw any sharp line between those in which the caudal filament is long and those in which it is short, or between those in which the second dorsal is straight or slightly concave, or deeply concave or subdivided. The nature of the claspers is not a satisfactory character for generic diagnosis, for it is not known for all species, and in any case it would apply to the male sex only. Therefore, we include all of the members of the family that lack an anal fin under the generic name that was earliest applied to any of them, i. e., *Hydrolagus* Gill 1862.

Key to Genera

1a. With a separate anal fin, sharply marked off from the caudal fin by a deep notch. *Chimaera* Linnaeus 1758, p. 524.

1b. Without a separate anal fin. *Hydrolagus* Gill 1862, p. 533.

Genus *Chimaera* Linnaeus 1758

Chimaera Linnaeus, Syst. Nat., *1*, 1758: 236; type species, *C. monstrosa* Linnaeus, Atlantic, designated by Jordan and Gilbert (Bull. U. S. nat. Mus., 16, 1883: 54).

Generic Synonyms:[40]

Chimera Rafinesque, An. Nature, 1815: 92; emended spelling for *Chimaera* Linnaeus 1758, by ref. to Linnaeus.
Chimaira Duméril, Mém. Acad. Sci. France, *27* (1), 1856: 155; emended spelling for *Chimaera* Linnaeus 1758, by ref. to Linnaeus.

Doubtful Synonyms:

Callorynchus Gronovius, Acta Helvet., *7*, 1772: 49; type and only described species, *C. atlanticus* Gronovius;[41] *C. centrina* also included by ref.; Gray, Cat. Fish. Coll. and Descr. by L. T. Gronow, in Brit. Mus., 1854: 16, for *C. atlanticus* Gronovius and *C. centrina* Gronovius.
Not *Callorynchus* Gronovius, Mus. Ichthyol., *1*, 1754: 59, pl. 4; Cuvier, Règne Anim., *2*, 1817: 140; and many subsequent authors; see discussion, p. 560, ftn. 121.
Not *Chimaera* Poli, Testacea ... Sicil., *1*, 1791: 31; for bivalve mollusks.
Not *Chimaera* Ochsenheimer, Schmetterlinge Europ., *2*, 1808: 1; for insects (Lepidoptera).
Not *Chimaera* Hitchcock, Ichthyol. New Eng., 1858: 118; for a reptilian fossil footprint.

Generic Characters. Chimaeridae with anal fin separated from caudal by a deep notch. Dorsal spine attached to anterior margin of first dorsal along basal $^1/_3$–$^1/_2$, then free; its free portion grooved along posterior side and with a more or less prominent row of pointed teeth directed toward the base along either margin of the groove. Second dorsal fin not partially subdivided, its upper margin straight or only weakly concave, much lower than first dorsal; connected with first dorsal by a low fold of skin without rays; its rear termination close to origin of caudal. Caudal fin lancet-shaped, about as

40. Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 487) includes the fossil genera *Plethodus* Dixon 1850 (Fossils of Sussex, 1850: 366) and *Dipristis* Gervais 1869 (Zool. Pal. Gen., 1869: 240) among the synonyms of the modern genus *Chimaera*.

41. Gronovius' description of his *C. atlanticus* fits well in the genus *Chimaera* except for his statement that there was no anal fin; but the latter is so inconspicuous that it may have been overlooked.

broad above axis as below, with longer or shorter terminal filament; its lower side (as determined by presence of horny rays) extending rearward as a narrow band for a considerable distance beyond termination of upper side. Eyes oval, their vertical diameter about $^1/_4$–$^1/_3$ as great as height of head at level of center of eye. Lower lip adnate to jaw centrally but forming a free fold on either side, continuous with outer subdivision of upper lip. Free tongue close-set with papillae. Roof of mouth strewn sparsely with small rounded knobs. Dental plates with thin outer and anterior margins forming a continuous cutting edge; anterior upper pair quadrangular, strongly cupped anteroposteriorly, the anterior part more or less distinctly sculptured with about 5–8 (perhaps more) low rounded radial ridges; posterior upper pair subtriangular to rhomboid, posterior part nearly flat transversely, with 1–4 low longitudinal ridges (tritors); lower plates rhomboid, the anterior margin more or less deeply excavate, the posterior part more or less deeply biconcave transversely, with prominent median elevation (tritor).

Claspers of male trifid in all members of the genus for which they are known;[42] the accessory third branch slender, rod-like and smooth-skinned, its tip more or less dilated, diverging from inner main branch and lying in a groove along ventral side of latter; each of the main branches much broader, fleshy, with rounded or truncate tip, the dorsal and lateral surfaces rough with small sharp thorn-like denticles directed toward base of clasper. Prepelvic tenacula with narrower anterior cartilage articulated to pelvis and broader posterior cartilage flexibly joined along anterior edge to anterior cartilage.

Egg Capsules.[43] Embryo case described as tadpole-shaped, with tapering rearward extension continuing as a filament; lateral flanges narrow, interrupted (or nearly so) abreast broadest part of embryo case, without transverse thickenings; both sides of capsule smooth; dorsal and ventral keels reported for some capsules but not for all. Opercular slits extending forward to anterior end of embryo case; their edges described as having "protruding *serrulae*, interlocking to form a close-set grating;"[44] also a considerable number of pores along edges of posterior extension of embryo case, some on dorsal side, some on ventral.[45] The opening by which the young fish escapes breaks across the anterior edge of the embryo case. No doubt the embryo lies with its right- and left-hand sides next to the sides of the case that bear the lateral flanges, since this is true of the closely related *Hydrolagus colliei* (p. 534). It is supposed that the egg capsules either lie free on the sea floor or that their tapering posterior extensions are partially implanted in the mud or sand.

Range. Representatives of the genus *Chimaera*, as here limited, are definitely known

42. The claspers of *C. pseudomonstrosa* Fang and Wang (Contr. biol. Lab. Sci. Soc. China, *8*, 1932: 280) from China have not been seen.

43. The earliest account of egg capsules of *Chimaera monstrosa* actually found in the oviducts of the parent fish seems to have been by Lilljeborg (Sverig. Norg. Fisk., *3*, 1884–1891: 527); the earliest description, with illustration, of capsules of proven identity was by Grieg (Bergens Mus. Aarb. [1894–1895], 5, 1896: 12–13). For more recent illustrations of the capsules of *C. monstrosa* and of the Japanese *C. phantasma*, with comparison of the two species, see Dean (J. Coll. Sci. Tokyo, *19* [3], 1904: 6, pl. 1, fig. 4; Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 35, 39, figs. 17, 21).

44. Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 28.

45. 75 pairs of these pores reported for *C. monstrosa*, 62 pairs for *C. phantasma* (Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 30).

in the eastern North Atlantic from Morocco, the Azores, and the Iberian peninsula (including the Mediterranean) to northern Norway, Iceland, and the Skagerrak; in the western Atlantic[46] from Cuban waters; from Japan; from northern China; also from South Africa (p. 526). The range of one of the species, *C. monstrosa*, includes the northeastern Atlantic northward from the Azores and Morocco and also South Africa, but not the intervening belt. Thus its distribution parallels that of certain Sharks and batoids.

Species. Six described species fall in the genus *Chimaera*. The two known from the North Atlantic, *C. monstrosa* of the eastern side and *C. cubana* from Cuban waters in the west, differ one from the other in the courses followed by the mucous canals on the head, in the height of the caudal fin relative to the second dorsal, and in other less obvious characters (p. 527). *C. jordani* of Japan and *C. pseudomonstrosa* of northern China are closely allied to *C. monstrosa*, but according to published accounts they appear to be separable from it by the differences given in the following Key.[47] The Japanese *C. phantasma* more closely resembles *C. cubana*.[48] *C. owstoni*, also from Japan, is marked off from all other members of the genus by its relatively larger anal fin and by the absence of a caudal filament.

Key to Species

1a. Tip of anal fin falling considerably short of rear end of base of second dorsal (Fig. 118C). *cubana* Howell-Rivero 1936, p. 527.

1b. Tip of anal fin extending at least as far as rear end of base of second dorsal (Fig. 118F).

2a. Caudal fin not prolonged as a filament. *owstoni* Tanaka 1905.[49] Japan.

2b. Caudal fin prolonged beyond rayed portion as a narrow filament.

3a. Rayed portion of upper side of caudal nearly or quite as high as posterior part of second dorsal above fleshy base.

4a. Anterior part of each anterior upper dental plate with 5–6 radial ridges.

5a. Horny rays of anterior part of first dorsal fin about 66 % as long as distance from tip of snout to external gill opening; ground tint on sides of trunk silvery.

monstrosa Linnaeus 1758.
Eastern North Atlantic from Morocco, the Azores and Mediterranean to northern Norway and Iceland, and the Skagerrak; also South African waters.[50]

46. It is probable that all reports of *Chimaera* from the fishing banks off New England and Nova Scotia were actually based on *Hydrolagus affinis* (p. 539).
47. We have seen neither *C. jordani* nor *C. pseudomonstrosa*.
48. We have at hand an excellent female of *C. phantasma*.
49. J. Coll. Sci. Tokyo, *20* (11), 1905: 10, pl. 1, figs. 2, 3; Fish. Japan, *1*, 1911: 18, pl. 5, figs. 17, 18.
50. This species has been credited repeatedly to the western North Atlantic also. But the *Chimaera* reported many years ago from Cuba as *C. monstrosa* has recently been found to be a separate species, *cubana* Howell-Rivero 1936

5b. Horny rays of anterior part of first dorsal about 80 % as long as distance from tip of snout to gill opening. Sides of trunk dark brown. *jordani* Tanaka 1905.[51]
Japan.

4b. Anterior part of each anterior upper dental plate with only 3 radial ridges. *pseudomonstrosa* Fang and Wang 1932.[52]
Northern China.

3b. Rayed portion of upper side of caudal only about half as high as posterior part of second dorsal above fleshy base.
phantasma Jordan and Snyder 1900.[53]
Japan.

Chimaera cubana Howell-Rivero 1936

Cuban Chimaera

Figures 118, 119, 120

Study Material. Male, 383 mm long, with very small claspers; male (type), 517 mm to upper origin of caudal, with well developed claspers; female, about 690 mm to upper origin of caudal (the posterior part of the caudal with its filament has been lost), all from Matanzas Bay, Cuba, now in Harvard Museum of Comparative Zoology.

Distinctive Characters. The only North Atlantic fishes with which *C. cubana* might be confused would be one of the other short-nosed chimaerids, i. e. *C. monstrosa*, *Hydrolagus affinis*, *H. alberti* or *H. mirabilis*. It is sharply marked off from the last three of these by the presence of a separate anal fin, distinct though small. In general appearance it resembles *C. monstrosa* closely, but it is separable from *monstrosa* by the facts that the upper side of its caudal fin is only about half as high as the posterior part of the second dorsal fin above the fleshy base, that the cranial mucous canal on each side of the head meets the aural canal at an acute angle (at about a right angle in *C. monstrosa*), that the rayed portion of the upper side of its caudal is only about as long as the distance from tip of snout to middle of eye (about as long as from tip of snout to rear of eye in *C. monstrosa*), and that the tip of its anal fin falls considerably short of the rear end of its second dorsal (anal extends as far as rear end of second dorsal in *C. monstrosa*).

Description. Proportional dimensions in per cent of distance between snout and origin of upper caudal fin. Male, 517 mm, the type, and female, 690 mm to origin

(p. 533), while reports of *C. monstrosa* from the fishing banks off New England and Nova Scotia seem actually to have been based upon *Hydrolagus affinis* (p. 539). The South African *Chimaera* was given a separate name, *vaillanti*, without description, by Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 7). But examination of the type specimen in the Paris Museum showed nothing to separate it from the northern *C. monstrosa* (see Barnard, Ann. S. Afr. Mus., *21* [1], 1925: 95).

51. J. Coll. Sci. Tokyo, *20* (11), 1905: 2, pl. 1, fig. 1, pl. 2, figs. 12–15.

52. Contr. biol. Lab. Sci. Soc. China, *8*, 1932: 280.

53. Proc. U. S. nat. Mus., *23*, 1900: 338; for detailed description and illustrations, see Dean (J. Coll. Sci. Tokyo, *19* [3], 1904: 3, pl. 1, figs. 3, 4).

of upper caudal, from Matanzas, Cuba (Harv. Mus. Comp. Zool., Nos. 1464 and 34728, respectively).

Trunk: breadth 12.0, 10.8; height 21.3, 21.0.
Snout length in front of: eye 9.7, 11.7; mouth 10.8, 12.9.
Eye: horizontal diameter 6.8, 6.5; vertical diameter 4.5, 4.4.

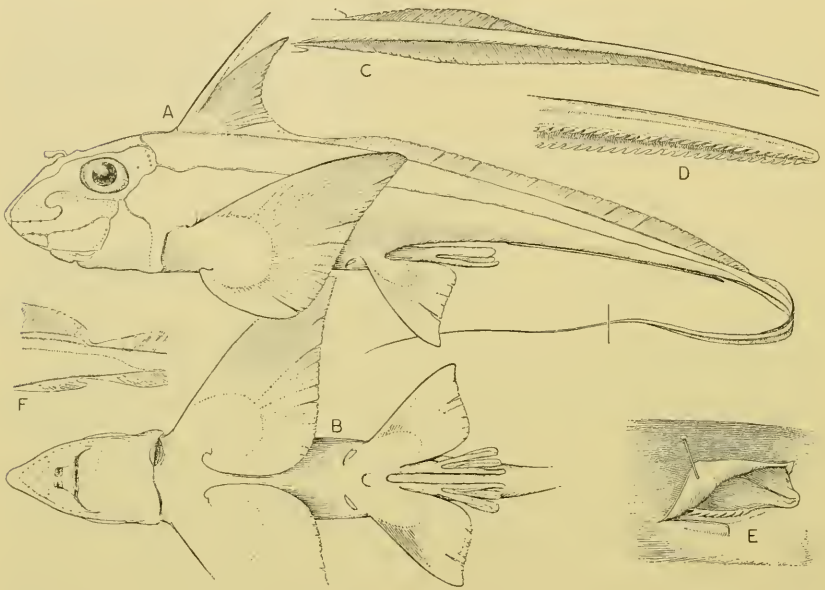

FIGURE 118. *Chimaera cubana*. *A* Male, 517 mm long to upper origin of caudal, from off Matanzas, Cuba (Harv. Mus. Comp. Zool., No. 1464, type), with caudal filament added from male 383 mm long to upper origin of caudal, from same locality (Harv. Mus. Comp. Zool., No. 1385). *B* Ventral view of same. *C* Caudal fin of same, about 0.6×. *D* Side view of free portion of dorsal spine of same, about 1.5×. *E* Prepelvic tenaculum of same with anterior end to the left, about 1.2×. *F Chimaera monstrosa*, female, 515 mm long, from Kattegat, to show anal fin.

Mouth: breadth 4.6, 4.8.
Distance between nostrils: 0.2, 0.4.
Dorsal spine: length 22.2, —.
First dorsal fin: length of base to lowest point between dorsals 16.2, 17.4.
Second dorsal fin: length of base 62.0, 61.0.
Upper caudal fin: length of base to last horny ray 11.8, —.
Lower caudal fin: length of base to last horny ray 34.0, —.
Pectoral fin: length 31.3, 29.0; breadth 17.8, 16.9.

Distance from snout to: origin of dorsal spine 21.1, 24.6; second dorsal 38.3, 42.7; pectoral 22.2, 23.6; pelvics 46.1, 50.0.

Distance from origin to origin of: pectorals and pelvics 23.8, 26.1; pelvics and lower caudal 52.8, 50.0.

Trunk about as high opposite dorsal spine (where highest) as distance from tip of snout to external gill opening and about 80 % of that height opposite origin of pelvic fins, tapering abruptly to genital openings and evenly thence rearward; strongly flattened sidewise rearward from head, its thickness $^1/_2$–$^1/_3$ as great as height opposite bases of pectoral fins and about half as great as height opposite bases of pelvic fins.

Skin perfectly smooth, without denticles, except on secondary sexual organs of males; pock-marked with many small, round, shallow depressions across anterior part of top of head.

Lateral mucous canal either with a definite series of short waves along flank or merely somewhat irregular;[54] junction between cranial and aural canals an acute angle; the jugular and oral canals meeting orbital canal separately but near together. A row of about 4–5 large and conspicuous pores close in front of occipital canal; a row of about 6 smaller pores close in front of descending branch of oral canal; about 10 small pores in anterior angle between oral and orbital canals; about 15–17 small pores in area partially enclosed by descending loop of orbital canal; about 5 or 6 small pores above orbital canal toward tip of snout; about 5 large openings along anterior part of orbital canal; about 6 large openings along angular canal to point where it divides, with 3 or 4 along each branch to front of snout; jugular canal without large openings, but continued as a line of short separate slits onto throat.

Head rounded, its length to origin of pectorals about 21–23 % of length of trunk to upper origin of caudal. Snout conical, its tip blunt and protruding slightly, the distance from tip of snout to level of fronts of eyes a little less than half of total length of head to origin of pectorals. Eye oval, its longitudinal diameter about 1.5 times the vertical diameter, its longitudinal axis dipping a little rearward, the pupil occupying a little more than half the total diameter; height of eye about 28–32 % of height of head; its length about $^1/_4$ (27 %) of length of head to pectoral origin. External gill openings a little longer than greatest diameter of eye, the distance between their lower ends a little more than half that long; opercular flaps entirely overlapping external gill openings, weakly convex rearward and thin-edged; their lower ends connected across throat by a conspicuous fold of skin, roofing a furrow directed rearward. Groove on lower side of head in front of nostrils more or less prominent, probably depending on muscular contraction. Inner subdivision of nostril (all that is seen unless nasal flaps are lifted) round or a little longer than broad, its greatest diameter about 15–16 % of greatest diameter of eye; distance from its rear side to rear margin of upper lip about as great as its diameter. Width of mouth when closed about as great as greatest diameter of eye.

54. On the specimen pictured (Fig. 118), the lateral canal is in regular waves on one side of the body but not on the other.

Upper anterior (vomerine) dental plates subtriangular, their outer anterior outlines convex, with 6–8 rodial ridges, the number increasing with growth.[55] Posterior upper (palatine) plates about 2.7 times as long as anterior plates, irregularly rhomboid, about twice as broad posteriorly as anteriorly; outer margin rounded with wear, without distinct radial ridges, but posterior surface with one large rounded prominence (tritor), its anterior outline somewhat indented. Lower (mandibular) plates about as long as posterior upper plates, of shape illustrated in Fig. 120, the edges more or less rounded,

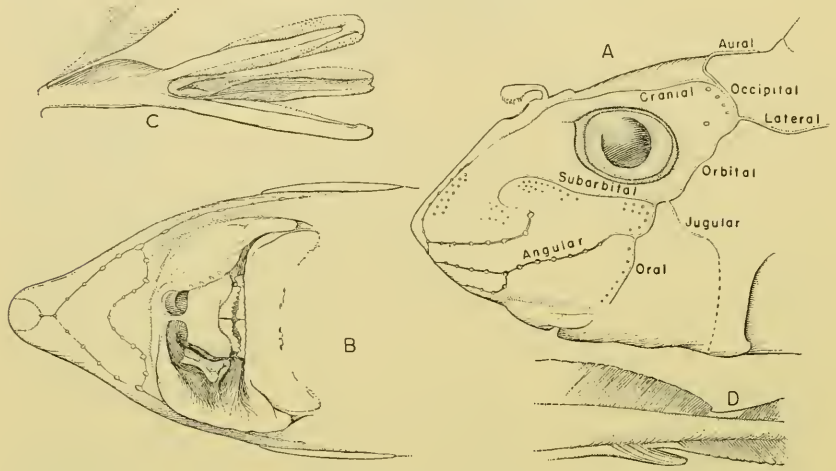

FIGURE 119. *Chimaera cubana*. *A* Side view of head of same specimen as in Fig. 118, to show mucous canals. *B* Ventral view of head of same. *C* Ventral view of clasper of same, about 0.7×. *D* Posterior part of dorsal fin, origin of caudal fin, and anal fin of female 690 mm long to upper origin of caudal fin, from off Matanzas, Cuba (Harv. Mus. Comp. Zool., No. 34728), about 0.5×.

with about 12 radial ridges on larger specimen;[56] the central part with one large rounded swelling (tritor).

Dorsal spine about as long as distance from tip of snout to origin of pectoral, its tip reaching a little beyond apex of first dorsal fin; its outer half free from fin, the rear surface with a longitudinal groove edged on each side with a series of 55–60 small sharp thorns pointing toward base and decreasing in size toward tip. First dorsal fin with narrowly pointed apex and moderately concave posterior margin, its base (origin of spine to bottom of interdorsal notch) about as long as its vertical height along anterior margin. Second dorsal separated from first by a low fold of skin without horny rays. Second dorsal with upper margin nearly straight, its height about as great at

55. Six ridges on specimen pictured (Fig. 120); apparently 8 or 9 on our largest specimen, but so worn down that an exact count cannot be made.

56. Too much worn down for accurate counting.

midlength as at anterior end and only about $^1/_{10}$ as great as length of dorsal spine; posterior end gently rounded. No definite interspace between second dorsal and origin of caudal. Height of upper side of caudal above axis about half as great as height of second dorsal, the length of rayed portion of caudal about as great as distance from tip of snout to middle of eye; lower side of caudal below axis about as wide as upper side or a little wider, the rayed portion extending rearward past termination of rayed upper side for a distance a little greater than length of latter, narrowing gradually; lower caudal origin a little anterior to upper origin. Caudal filament, beyond most posterior ray on lower side of caudal fin, nearly as long as distance from snout to origin of pelvic fins on small specimen, perhaps on large as well,[57] tapering to a hair-like tip. Anal fin so small that it is likely to be overlooked, sharply marked off from caudal by a narrow notch reaching to ventral line of trunk, of form illustrated in Fig. 118, its posterior margin about $^1/_3$ as long as eye, its tip falling a little short of level of upper origin of caudal; apex rounded; rayed portion of base about as long as posterior margin, continuing forward as a low fleshy fold distinguishable a little more than half of the distance toward bases of pelvic fins. Pelvic fins with nearly straight anterior margin, weakly concave distal margin, and moderately convex inner margin; apex abruptly rounded, posterior corner much more broadly so; anterior margin shorter than head to origin of pectoral by a distance about as long as eye; pelvic origins posterior to axils of pectorals by a distance about as great as that from tip of snout to origin of pectorals. Pectoral fins about 1.2–1.4 times as long as head to pectoral origins, extending a little beyond rear end of bases of pelvic fins when laid back; anterior margin weakly and evenly convex, distal margin weakly concave, inner margin moderately convex with well marked re-entrant notch at axil, of form shown in Fig. 118; tip abruptly rounded, posterior corner much more broadly so; maximum breadth a little more than half (50–56 %) as great as length of anterior margin.

Secondary Sexual Characters. Postanal ventral pad (p. 523) of females about 1.25–1.33 times as long as eye, its origin posterior to base of pelvics by a distance about 1.5 times length of eye.

Frontal tenaculum of males about half as long as eye; dorsal profile curved, corresponding to profile of head; tip club-shaped, thickly set below with sharp thorns pointing rearward. Prepelvic tenacula paddle-shaped, about $^2/_3$ as long as eye when fully exposed; extreme breadth about $^2/_3$–$^3/_4$ as great as their length; anterior margin hard, with a single row of about seven sharp curved teeth directed toward base; posterior part soft, the median face with a thin flap of skin folded over toward base. Openings of prepelvic pouches about half as long as eye, at an angle of about 45° with the main axis of the trunk, their inner ends forward. The tenacula, when retracted, are entirely concealed within the pouches, with the lips of the latter then somewhat rolled inward.

Claspers of largest male seen[58] reaching about to tips of pelvic fins when latter

57. The caudal filament has been damaged on the two larger specimens we have seen.
58. Perhaps not quite full grown.

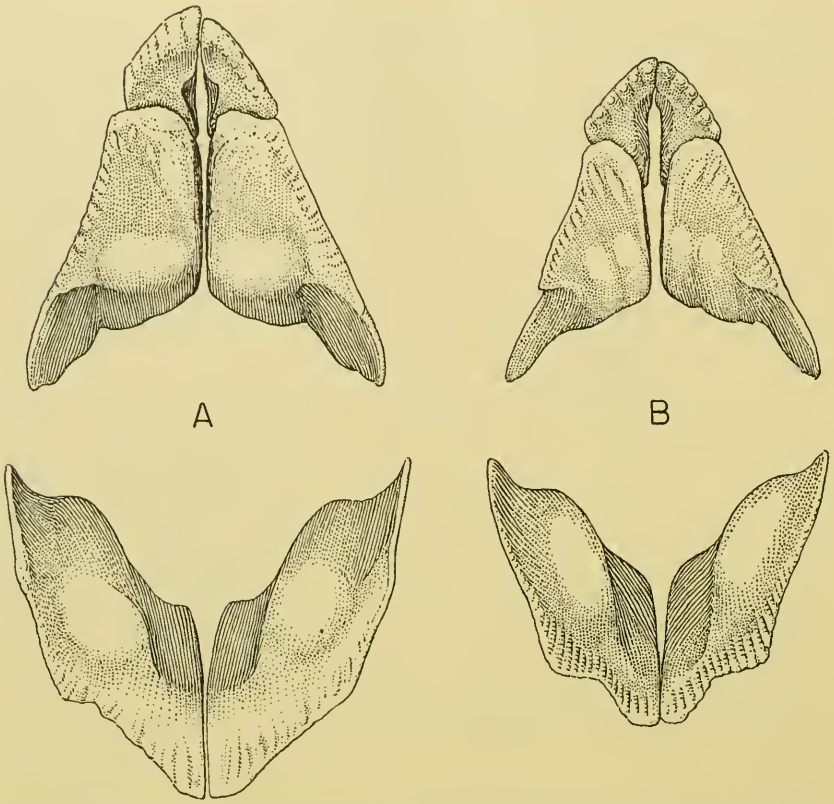

FIGURE 120. *Chimaera cubana.* Upper dental plates (above) and lower dental plates (below) of *A* Female, 690 mm long to upper origin of caudal fin, and *B* Male, 517 mm long to upper origin of caudal fin, both from Matanzas, Cuba (Harv. Mus. Comp. Zool., Nos. 34728 and 1464), about 1.75×.

are laid back, subdivided about midway of their lengths; the accessory third branch a little the longest of the three, its tip not dilated; the apposed surfaces of all three branches rough nearly to the tips with many thorns pointing toward the base; outer surfaces of the two broader branches also thorny.

Color. Upper parts of trunk described as silvery gray (dull gray after preservation) without definite markings, darkest on top of head and along back, shading to almost white on lower surface; first dorsal blackish toward tip; second dorsal and upper caudal also blackish along upper half, the lower caudal more conspicuously so; anal as well as ventral ridge extending forward from it, black; pelvics sooty-edged; pectorals

narrowly edged with sooty or blackish, their rayed portions otherwise amber gray on preserved specimens; dental plates amber, the swellings (tritors) on the palatine and mandibular plates white.

Size. The claspers of males of 700–750 mm (to lower termination of caudal fin) appear to be fully developed. The largest specimen seen (female in Study Material) is about 695 mm long to the upper origin of the caudal (most of fin lost).

Developmental Stages. The egg capsules have not been seen.

Habits. We know only that the few specimens seen recently were taken in deep water, one of them at 240 fathoms.[59]

Range. Known only from Matanzas Bay, Cuba. Seven specimens have been reported, two of them taken in 1865, one in 1876, and four between 1912 and 1934. But a more thorough exploration of the fish fauna around Cuba in depths of 200–500 fathoms, with gear adapted to catching chimaerids, may prove that it is more plentiful than the paucity of printed reports might suggest.

Synonyms and References:

Chimaera monstrosa Poey, Repert. Fisico-Nat. Cuba, *1*, 1866: 242 (diagn., Matanzas, Cuba); *2*, 1868: 445; also Synop. Pisc. Cubens., 1868: 445 (diagn., Matanzas, Cuba); Enumerat. Pisc. Cubens., An. Soc. esp. Hist. nat., *4*, 1876: 182, pl. 8 (descr., ills., Matanzas, Cuba).

Chimaera cubana Howell-Rivero, Proc. Boston Soc. nat. Hist., *41*, 1936: 50, pl. 13 (descr., ill., cf. *C. monstrosa*, Matanzas, Cuba, from deep water).

Not *Chimaera monstrosa* Linnaeus, Syst. Nat., *1*, 1758: 236; eastern Atlantic.

Genus *Hydrolagus* Gill 1862

Hydrolagus Gill, Proc. Acad. nat. Sci. Philad., 1862: 331; type and only included species, *Chimaera colliei* Lay and Bennett (Zool. Beechey's Voy., Fishes, 1839: 71, pl. 23, figs. 1, 2). Off Monterey, California.

Generic Synonyms:

Callorhynchus Goode and Bean, Smithson. Contr. Knowl., *31*, 1895: also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 3,[60] pl. 10, fig. 36; erroneous caption for ill. of *Hydrolagus colliei*, after Lay and Bennett (Zool. Beechey's Voy., Fishes, 1839: pl. 23, fig. 1).

Chimaera (in part) Lay and Bennett, Zool. Beechey's Voy., Fishes, 1839: 71; for *C. colliei* Lay and Bennett; also subsequent authors for other species.

Bathyopolex (subgenus of *Chimaera*) Collett, Forh. VidenskSelsk. Krist., 9, 1904: 5; type species, *Chimaera* (*Bathyopolex*) *mirabilis* Collett. Faroe Channel and Faroe Bank, 720–1,200 m.

Bathyopolex (genus) Jordan and Hubbs, Mem. Carneg. Mus., *10*, 1925: 118; for *Chimaera barbouri* Garman 1908. Japan.

Psychichthys (subgenus of *Hydrolagus*) Fowler, Proc. Acad. nat. Sci. Philad., *59*, 1902: 419; type species, *Hydrolagus waitei* Fowler. Southeastern Australia.

Psychichthys (genus) Jordan and Hubbs, Mem. Carneg. Mus., *10*, 1925: 117; for *P. eidolon* Jordan and Hubbs. Japan.

Phasmichthys Jordan and Hubbs, Mem. Carneg. Mus., *10*, 1925: 119; type species, *Chimaera mitsukurii* Dean (J. Coll. Sci. Tokyo, 19 [3], 1904: 6, pl. 1, figs. 1, 2). Japan.

Not *Chimaera* Linnaeus, Syst. Nat., *1*, 1758: 236.

Not *Callorynchus* Gronovius 1754, Cuvier 1817, and subsequent authors; see p. 560, footnote 121.

Not *Callorynchus* Gronovius 1772; probably equals *Chimaera* Linnaeus 1758; see p. 560, footnote 121.

Not *Callorhinchus* Lacépède 1798, see p. 560, footnote 121.

59. Howell-Rivero, Proc. Boston Soc. nat. Hist., *41*, 1936: 50.

60. List of plates and figures.

Generic Characters. No separate anal fin. Dorsal spine either free along its outer $^1/_2$–$^1/_3$ or joined with anterior margin of first dorsal out to its tip, its posterior face smooth or with double row of recurved thorns. Second dorsal fin continuous basally from end to end, its upper margin straight or more or less deeply concave. Caudal filament ranging from long to so short as to be almost unrecognizable. Claspers of males trifid in some, bifid in others.[61] Other characters as in *Chimaera* (p. 524).

Developmental Stages. The egg capsules of the species from which they are known closely resemble those of *Chimaera*.[62]

Range. The known range of the genus includes: both sides of the North Atlantic, in the east from Portugal to the Faroe Channnel and Faroe Bank, in the west in the Gulf of Mexico and on the continental slope off New England and Nova Scotia; the Pacific Coast of North America from the northern part of Lower California to western Alaska;[63] the vicinity of the Hawaiian Islands; Japan; the Philippines; southern and southwestern Australia, Bass Strait and Tasmania; New Zealand; and the Natal Coast of South Africa. The depth range of one or another species in different seas extends from close to the surface down at least to 1,000 fathoms and perhaps deeper.[64]

Species. Three species are known in the North Atlantic: *H. affinis* (Brito Capello) 1867, with second dorsal of about even height from end to end, short caudal filament, and short pectorals; *H. alberti* Bigelow and Schroeder 1951 with second dorsal of about even height, very long caudal filament and larger pectorals; and *H. mirabilis* (Collett) 1904, with deeply concave second dorsal, long caudal filament, and longer pectorals. The first of these has a close counterpart in the Japanese *H. eidolon* (Jordan and Hubbs) 1925, the second in *H. mitsukurii* (Dean) 1904, also from Japan. But in each case the differences between the Atlantic and Japanese members of each pair of species (see accompanying Key) seem sufficient for specific separation. Nine other named species are perhaps separable by the characters given in the following Key. But critical comparison of adequate series of specimens from different regions may result in some reduction in the number of supposed species.

Provisional Key to Species

1a. Upper margin of second dorsal either straight, or if notched, the anterior part of fin is connected basally with posterior part by an unbroken series of horny rays.

61. Trifid in *H. affinis* (Brito Capello) 1868 and *H. ogilbyi* (Waite) 1898; bifid in *H. colliei* (Lay and Bennett) 1839, *H. mirabilis* (Collett) 1904, *H. mitsukurii* (Dean) 1904, and *H. novae-zealandiae* (Fowler) 1911; not known for *H. africanus* (Gilchrist) 1922, *H. eidolon* (Jordan and Hubbs) 1925, *H. deani* (Smith and Radcliffe) 1912, *H. lemures* (Whitley) 1939, *H. purpurescens* (Gilbert) 1905, *H. waitei* Fowler 1908, or *H. alberti* Bigelow and Schroeder 1951.

62. See Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 40–41, figs. 24–29, pl. 2, figs. 8–11, pl. 3) for *H. colliei* (Lay and Bennett) 1839, California; Whitley (Fish. Aust., *1*, 1940: 46, 47, fig. 32) for *H. ogilbyi* (Waite) 1898, Australia; see also Dean (J. Coll. Sci. Tokyo, *19* [3], 1904: pl. 1, fig. 2) and Holt and Byrne (Fish. Ireland Sci. Invest. [1908], 4, 1910: 13, pl. 4, figs. 1, 2) for egg capsules presumed to be those of *H. mitsukurii* (Dean) 1904, from Japan, and of *H. mirabilis* (Collett) 1904, from the northeastern Atlantic, respectively.

63. A specimen of *H. colliei* has been reported recently from Enseñada, Lower California (Fitch, Calif. Fish Game, *35*, 1949: 44); formerly it was thought to reach its most southerly limit near San Diego, California.

64. *H. affinis* has been caught as deep as 963 fathoms off southern New England (p. 544); *H. alberti* was taken in 305 fathoms in the Gulf of Mexico; the only specimen of *H. purpurescens* that has been seen was taken in a trawl haul where the depth was between 975 and 1,067 fathoms (Gilbert, Bull. U. S. Bur. Fish., *23* [2], 1905: 582).

2a. Tip of pectoral fin not reaching beyond origin of pelvics when laid back.

3a. Pectoral fins reaching nearly to origin of pelvic fins when laid back; height of second dorsal at midlength not more than $^1/_5$ as great as length of anterior margin of first dorsal; apex of first dorsal angular; cranial mucous canal on each side without a downward wave close in front of level of front of eye; jugular and joint oral-angular canals extending downward as a single trunk for some distance from the point where they meet orbital canal (Fig. 121). *affinis* (Brito Capello) 1867, p. 539.

3b. Pectoral fins falling considerably short of origin of pelvic fins when laid back; height of second dorsal at midlength about $^1/_4$ as great as length of anterior margin of first dorsal; apex of first dorsal rounded; cranial mucous canal on each side with a pronounced downward wave close in front of level of front of eye; jugular and joint oral-angular canals diverging at once from point where they depart from orbital canal.

eidolon Jordan and Hubbs 1925.[65]
Japan.

2b. Tip of pectoral fin reaching beyond origin of pelvic fins when laid back.

4a. Pectoral fin considerably shorter than head from tip of snout to gill opening. *waitei* Fowler 1908.[66]
Victoria, Australia.

4b. Pectoral fin considerably longer than head from tip of snout to gill opening.

5a. Dorsal spine considerably longer than distance from tip of snout to origin of pectoral fins. *africanus* (Gilchrist) 1922.[67]
Natal Coast, South Africa, to Cape of Good Hope.

5b. Dorsal spine not longer than distance from tip of snout to origin of pectoral fins.

6a. Second dorsal fin with upper margin deeply concave, its height at midlength only half as great as height at anterior end, or less.

7a. Lower surface white, ground tint of sides silvery, the back brown with whitish spots.

colliei (Lay and Bennett) 1839.[68]
Pacific Coast of North America, from Enseñada, Lower California to western Alaska (see p. 535, footnote 68).

7b. Lower surface dark brown or blackish, as dark as sides and back.

65. Mem. Carneg. Mus., *10*, 1925: 117, pl. 5, fig. 1.
66. Proc. Acad. nat. Sci. Philad., *59*, 1908: 419.
67. Fish. Mar. biol. Surv. S. Afr., Rep. 2, Spec. Rep. 3 (1921), 1922: 31, pl. 8, as *Chimaera africana*; Smith, Sea Fish. S. Afr., 1949: 76.
68. The original illustration by Lay and Bennett (Zool. Beechey's Voy., 1839: Fishes, 71, pl. 23, figs. 1, 2) is excellent, except that the clasper is shown as trifid, apparently as the result of mutilation. For more recent colored illustrations, see Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: pl. 10 [young], pl. 11 [partly grown female]).

8a. Caudal filament at least as long as distance from tip of snout to origin of caudal fin; jugular mucous canal meets oral canal some distance downward from orbital canal.

9a. First dorsal fin with apex extending considerably beyond tip of spine, its anterior margin considerably longer than distance from tip of snout to external gill opening; second dorsal about half as high at midlength as at anterior end. *deani* (Smith and Radcliffe) 1912.[69]
Philippines.

9b. First dorsal fin with apex about level with tip of spine, its anterior margin not longer than distance from tip of snout to external gill opening; second dorsal only $^1/_5$–$^1/_3$ as high at midlength as at anterior end.
mirabilis (Collett) 1904.[70]
Northeastern Atlantic, Faroe Bank and Channel, Irish slope.

8b. Caudal filament not longer than distance from tip of snout to external gill opening; jugular mucous canal and oral canal meet orbital canal separately.
barbouri (Garman) 1908.[71]
Japan.

6b. Second dorsal fin with upper margin straight or only weakly concave, its height nearly or quite as great at midlength as at anterior end.

10a. Dorsal spine attached to anterior edge of first dorsal fin nearly or quite to its tip, without marginal thornlets, its posterior side not grooved; apex of first dorsal rounded. *purpurescens* Gilbert 1905.[72]
Off Hawaiian Islands.

10b. At least outer half of dorsal spine free

69. Proc. U. S. nat. Mus., *42*, 1912: 232; *Chimaera deani*.

70. Forh. VidenskSelsk. Krist., 9, 1904: 5; Rep. Norweg. Fish. Invest., *2* (2), 1905: 35, pl. 1, fig. 4; Holt and Byrne, Fish. Ireland Sci. Invest. (1908), 4, 1910: 11, pl. 2; Koefoed, Rep. Sars N. Atlantic Deep Sea Exped. (1910), *4* (1), 1932: 29, fig. 3.

71. Bull. Mus. comp. Zool. Harv., *51*, 1908: 255; *Chimaera barbouri*. On the type specimen (Harv. Mus. Comp. Zool., No. 1281), the second dorsal fin is about half as high at the midlength as at the anterior end. But Tanaka (Fish. Japan, *1*, 1911: 17, pl. 4, fig. 1) describes and pictures another Japanese specimen as *barbouri* with the second dorsal so deeply concave that the fin is nearly subdivided.

72. Bull. U. S. Bur. Fish., *23* (2), 1905: 582, fig. 231. Garman (Mem. Harv. Mus. comp. Zool., *40*, 1911: 90) considered *purpurescens* Gilbert 1905 preoccupied by *C. purpurascens* Jordan and Snyder 1904 (Smithson. misc. Coll., *45*, 235), and hence he proposed the specific name *gilberti* to replace the former. But this change is not needed according to the International Rules of Zoological Nomenclature (see Proc. biol. Soc. Wash., *39*, Art. 35, 1929: 87).

from anterior margin of first dorsal fin, its posterior free surface with a longitudinal groove, each margin of the latter with a row of small sharp thornlets directed downward; apex of first dorsal angular.

11a. Caudal filament not longer than distance from tip of snout to external gill opening.

ogilbyi (Waite) 1898.[73]
Southern Australia, Tasmania, Japan; also *tsengi* (Fang and Wang) 1932, China.

11b. Caudal filament at least as long as distance from tip of snout to origin of pelvic fins, or longer.

12a. Pectoral fin about 1.5 times as long as head from tip of snout to upper origin of pectoral; oral canal meets jugular canal some distance below point where latter meets orbital canal.

13a. Tips of pectorals reaching beyond origins of pelvics when laid back; dorsal spine only about $^3/_4$ as long as distance from tip of snout to gill opening; lateral line with a pronounced wave below dorsal spine.

alberti Bigelow and Schroeder 1951, p. 545.

13b. Tips of pectorals falling short of origins of pelvics when laid back; dorsal spine as long as

73. Prelim. Rep. 'Thetis,' 1898: 41, pl. 11. According to the two most detailed descriptions of this species (Waite, Mem. Aust. Mus., 4, 1899: 48, pl. 8; Tanaka, J. Coll. Sci. Tokyo, *23*, 1908: 12), the caudal filament is at least as long as the distance from the tip of the snout to the rear edge of the eye; but the caudal has been characterized more recently as "hardly filamentous" (Whitley, Fish. Aust., *1*, 1940: 233). In *tsengi* Fang and Wang (Contr. biol. Lab. Sci. Soc. China, *8*, 1932: 281, fig. 29), the caudal filament, while described as long, is pictured as somewhat shorter than the distance from the tip of the snout to the gill openings. *H. tsengi* closely resembles *H. ogilbyi*, except that it is described as light brown (in formalin), not silvery. We hesitate to judge from the published accounts whether it is actually distinguishable from *ogilbyi*.

distance from tip of snout to gill opening; lateral line with only a low wave below dorsal spine.

mitsukurii Dean 1904.[74]
Japan.

12 b. Pectoral fin only as long as distance from tip of snout to upper origin of pectoral, or a little longer; jugular and oral canals meet orbital canal separately.

14 a. First and second dorsal fins separated by an interspace about as long as eye; posterior outline of second dorsal abruptly rounded; lateral line not in short waves but merely somewhat irregular along flanks; sides cream-colored and silvery with irregular darker brown margins.

novae-zealandiae (Fowler)[75] 1911.
New Zealand.

14 b. First and second dorsal fins scarcely separated at base; posterior outline of second dorsal sloping evenly downward; lateral line along flanks in a

74. Dean, J. Coll. Sci. Tokyo, *19* (3), 1904: 6, pl. 1, figs. 1, 2; Jordan and Snyder, Proc. U. S. nat. Mus., *27*, 1904: 224, fig. 2. The caudal filament is pictured as being only about as long as the distance from the tip of the snout to a little beyond the bases of the pelvics; but it is considerably longer in an excellent specimen that we have examined, and hair-fine toward the tip.

75. Proc. Acad. nat. Sci. Philad., *62*, 1911: 603; see also Griffin, Trans. Proc. N. Z. Inst., *54*, 1923: 246, pl. 20, fig. 2.

series of many short waves; sides greyish without dark markings. *lemures* Whitley 1939.[76] Great Australian Bight, off southwestern Australia, 80–320 fathoms.

1 b. Upper margin of second dorsal so deeply notched that anterior rayed portion is entirely separated from posterior rayed portion. *media* Garman 1911. Locality unknown.[77]

Hydrolagus affinis (Brito Capello) 1867

Deep-water Chimaera

Figure 121

Study Material. Female, 973 mm long to origin of upper caudal fin, from Banquereau Bank off eastern Nova Scotia, in Museum of Comparative Zoology, and male, 797 mm, from same locality, in U. S. National Museum.

Distinctive Characters. The only North Atlantic fishes with which *H. affinis* might be confused are *Chimaera monstrosa* (p. 526), *C. cubana* (p. 527) and *Hydrolagus alberti* (p. 545). It is easily separable from the first two of these in that it lacks a separate anal fin, that the tip of its pectoral fin, when laid back, does not overlap the origin of the pelvic fin, that it has only a short caudal filament, and that it is dark brown in color with its abdomen no paler than its sides or back. Its short caudal filament and short pectorals also mark it off from *Hydrolagus alberti.*

Description. Proportional dimensions in per cent of distance between snout and origin of upper caudal fin. Male, 797 mm long to origin of upper caudal, from Banquereau Bank off Nova Scotia (U. S. Nat. Mus., No. 38021). Female, 973 mm, also from Banquereau Bank (Harv. Mus. Comp. Zool., No. 818).

Trunk: breadth 9.0, 10.3; height 19.4, 19.5.

Snout length in front of: eye 9.7, 10.8; mouth 10.0, 9.6.

Eye: horizontal diameter 5.1, 4.8; vertical diameter 4.4, 3.6.

Mouth: breadth 5.7, 5.0.

Nostrils: distance between —, 0.2.

Dorsal spine: length 15.7, —.

First dorsal fin: length of base to lowest point between dorsals 20.0, 18.3.

76. Aust. Zool., *9*, 1939: 261, pl. 23, fig. 2; Fish. Aust., *1*, 1940: 236, fig. 272.

77. A female and an adult male, on which Garman based his description (Mem. Harv. Mus. comp. Zool., *40*, 1911: 91) are still in excellent condition, though received at the Museum at some time before 1872. There is no record of their source.

Second dorsal fin: length of base 59.5, 59.0.
Upper caudal fin:[78] length of base to last horny ray 17.1, 13.4.
Pectoral fin: length 33.9, 28.3; breadth 13.8, 14.4.
Distance from snout to: origin of dorsal spine 20.5, 22.6; 2nd dorsal 38.9, 41.3; pectoral 21.8, 22.4; pelvics 49.2, 52.8.
Distance from origin to origin of: pectorals and pelvics 30.1, 31.1.

Trunk about as high opposite dorsal spine (where highest) as distance from tip of snout to origins of pectorals, about $^2/_3$ as high close behind pelvics, tapering evenly thence rearward; strongly compressed laterally posterior to head, its sides almost flat, its thickness a little less than half as great as its height opposite bases of pectoral fins and only about $^1/_3$ as great as its height opposite bases of pelvic fins.

Skin perfectly naked on adults, except for claspers and tenacula of males (see Description, p. 543), but closely pock-marked with a great number of rounded depressions of different sizes on top and on upper sides of head abreast of mouth and nostrils.

Lateral mucous canal in a series of low irregular waves along flanks, descending at origin of caudal fin to follow out along lower edge of caudal axis as in *Chimaera;* junction of cranial canal with aural canal a little more acute than a right angle; anterior course of cranial canal nearly straight, not looping downward in front of eye; jugular and oral canals running downward from suborbital as a joint canal for some distance before separating. About 10 medium-size pores close in front of occipital canal; about 5–6 pores in area bounded by suborbital and joint oral-jugular canals; about 8 large openings along angular canal to front of snout; a double row of about 6–7 irregular pairs of small pores parallel to descending oral branch and close in front of it; about 8–9 large openings along anterior part of suborbital canal from its descending wave to front of snout; jugular canal continued downward onto throat as a series of short slits as in *Chimaera.*

Head about 21–22% of length of trunk to upper origin of caudal fin. Snout low-conical with blunt tip.[79] Eye oval, sloping a little rearward, its horizontal diameter about 1.2–1.3 times its vertical diameter; distance from tip of snout to front of eye about half of length of head to origin of pectorals; pupil a little less than half vertical diameter of eye; height of eye about $^1/_5$ (21%) of height of head, its length about $^1/_5$ (21–22%) of length of head to origin of pectorals. Gill openings about half as long as distance from tip of snout to front of eye, the distance across throat between their lower ends about as long as eye. Fold across throat strongly marked, as in *Chimaera cubana* (p. 529). Groove around nostrils on lower side of head only faintly distinguishable on specimens seen. Exposed subdivision of nostrils oval or quadrate with rounded corners, about twice as long as broad, its length about 30% as great as length of eye; distance from its own rear edge to free edge of upper lip about as long as its own length. Width

78. The point of origin of the lower caudal fin is not evident.
79. The illustration by Goode and Bean (Smithson. Contr. Knowl., *31*, 1895: pl. 10, fig. 32), which has been copied repeatedly, shows the snout as more contracted than it is on our specimens.

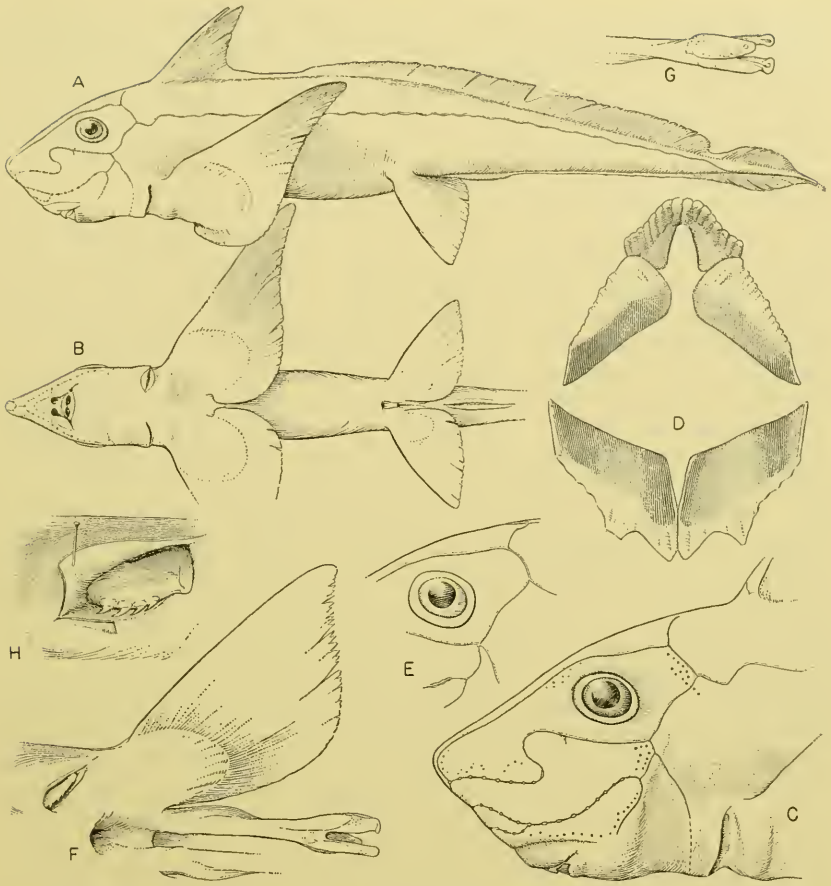

FIGURE 121. *Hydrolagus affinis*. *A* and *B* Side and ventral views of female, 973 mm long to upper origin of caudal fin, Banquereau Bank (Harv. Mus. Comp. Zool., No. 818). *C* Side view of head of same to show mucous canals, about 0.25×. *D* Upper dental plates (above) and lower dental plates (below) of same, about 0.8×. *E* Mucous canals above and below eye of male, about 797 mm long, from same locality (U. S. Nat. Mus., No. 38201), about 0.25×. *F* Ventral view of prepelvic tenaculum, clasper, and ventral fin of same, about 0.4×. *G* Dorsal view of clasper. *H* Prepelvic tenaculum of same with anterior end to the left, about 0.8×.

of mouth, when closed, a little greater than length of eye (about 1.1 times). Tongue with many low papillae.

Anterior upper (vomerine) dental plates strongly cupped front to rear, anterior contour concave, conspicuously scalloped, with 7–8 radial ridges. Posterior upper

(palatine) plates about twice as long as anterior plates, about $^2/_3$ (66 %) as long as eye and about 1.6 times as long as broad; exposed part subtriangular, weakly convex transversely, outer margin slightly irregular but without definite radial ridges, inner anterior part with one low rounded prominence (tritor). Lower (mandibular) plates of shape shown in Fig. 121, the anterior margin deeply excavated with prominent outer and inner angles; without radial ridges but with one round or oval swelling (tritor) near outer anterior corner.

Dorsal spine[80] as pictured, about as long as distance from tip of snout to rear edge of eye, reaching about to apex of first dorsal fin; outer part free, the rear face with two rows of sharp thorns pointing toward base, as in *Chimaera*. First dorsal fin with angular apex and moderately concave posterior margin; its base (from origin of spine to bottom of interdorsal notch) about $^2/_3$ (65–66 %) as long as height along anterior margin. Distance between first dorsal and first sensible elevation of second dorsal a little more than half (52–53 %) as long as anterior margin of first dorsal. Second dorsal fleshy with only outer parts of horny rays visible; upper margin nearly straight; height at midlength a little less than $^1/_5$ (18–19 %) as great as length of anterior margin of first dorsal; about equally great at anterior end and little greater at rear end; posterior outline of second dorsal curving abruptly downward.[81] No definite interspace between second dorsal and upper origin of caudal. Caudal lanceolate, tapering to narrow tip, prolonged as a short filament;[82] maximum height of caudal above axis a little less (80 %) than height of second dorsal at posterior end; its extreme length to most posterior ray between 4.5 and 4.75 times as great as its height; caudal below axis a little narrower (about 80–81 %) than above axis; most posterior ray of lower side posterior to most posterior ray of upper side by a distance about equal to length of upper side; origin of lower side of caudal indefinite in position, preceded by a low fleshy ridge distinguishable forward for a distance about as long as upper side of caudal. Pelvic fins with weakly convex anterior margin, slightly more convex distal margin, subangular outer corners, and gradually rounded posterior (inner) corners; length of pelvics along anterior margin about as great as distance from tip of snout to rear margin of eye; pelvics originating posterior to axils of pectorals by a distance about 1.2–1.3 times as great as distance from tip of snout to origin of pectorals. Pectoral fins about 1.3–1.5 times as long as distance from tip of snout to pectoral origins; tips, when laid back, falling a little short of origins of pelvics on specimens seen, but perhaps reaching to origin of pelvics in some cases; anterior margin of pectorals weakly convex; distal margin weakly concave; apex narrowly rounded; inner corner broadly so; inner margin with conspicuous notch at axil.

Secondary Sexual Characters. Female without prepelvic openings. Ventral pad a little shorter than distance from tip of snout to front of eye, its anterior end posterior to bases of pelvics by a distance about as long as eye.

80. The spine has lost its tip on our specimens.
81. The margin of the second dorsal is deeply indented on our specimen about midway of its length, no doubt as result of injury.
82. The filament is less than half as long as the eye on our specimen, though seemingly intact.

Frontal tenaculum of males armed below with many sharp thorns pointing toward base.[83] Prepelvic tenacula about 70 % as long as eye and about 1.3 times as long as broad; the terminal outline of the posterior cartilage deeply concave, but not the skin covering it; outer margin of blade with 4–5 stout hooks, progressively smaller from front to rear. Apertures of prepelvic pouches about half as long as eye, diverging rearward at an angle of about 45° with longitudinal axis of trunk.

Claspers, on specimen seen, between 3/4 and 1/5 as long as anterior margin of pelvic fins, divided between 2/3 and 3/4 the distance outward from their bases; the accessory third branch rod-like with narrow lateral expansions of skin, its tip sometimes somewhat curved but not dilated; the two other branches more fleshy with broader lateral wings and bluntly truncate tips; the apposed surfaces of the two broader branches rough with many small thorns directed toward the base, much as in *Chimaera*, and likewise their outer faces here or there; the narrower third branch smooth basally, but its terminal half rough outwardly as well as inwardly. Sperm channel an open groove basally along proximal part of clasper but continued rearward as a closed canal to point at which the terminal branches of clasper separate.

Color. Trunk uniformly lead color, tan brown, or dark sepia below as well as above; chin and throat considerably paler and snout grayish; second dorsal fin either whitish or leaden along margin; posterior margin of first dorsal, posterior and inner margins of pelvics and posterior margin of pectorals narrowly edged with dark sepia or blackish; fins otherwise a little paler than general shade of sides; dental plates pale grayish but the tritors greenish white; tongue purple.[84]

Relationship to Extralimital Species. It has been suggested[85] that *H. affinis* may prove identical with *H. africanus* (Gilchrist) 1922 from the Natal Coast of South Africa. But it appears from the published account and illustration of *africanus*[86] that its dorsal spine is much longer relatively than that of *affinis*, its first dorsal fin correspondingly higher and its pectoral considerably longer. *H. eidolon* (Jordan and Hubbs) 1925 from Japan closely resembles *affinis*. But available information[87] suggests that it is separable from the latter by the characters stated in the Key (p. 535).

Size. The largest specimen reported (a female) was about 49 inches long and weighed 17 1/2 pounds dressed.[88]

Habits. Evidently this chimaeroid is confined to moderately deep water, all specimens for which depth of capture was recorded having been brought up from between about 160 and 1,290 fathoms. Nothing more is known of its habits.

Range. Both sides of North Atlantic in moderately deep water; in the east, off the coast of Portugal; in the west, continental slope northward and eastward from the

83. The only male we have seen has lost the tenaculum.
84. After many years in alcohol.
85. By Norman, 'Discovery' Rep., *12*, 1935: 47.
86. Gilchrist, Fish. Mar. biol. Surv. S. Afr., Rep. 2, Spec. Rep. 3 (1921), 1922: 31, pl. 8.
87. Jordan and Hubbs, Mem. Carneg. Mus., *10*, 1925: 117, pl. 5, fig. 1.
88. Taken about 85 miles off Cape Sable, Nova Scotia, from between 400 and 500 fathoms, October 15, 1930; see Firth, Bull. Boston Soc. nat. Hist., 61, 1931: 9.

offing of Cape Cod, Lat. 39°47′ N, Long. 70°31′ W, to Banquereau Bank off eastern Nova Scotia and to the slope of the Grand Banks off Newfoundland.[89]

Occurrence in the Western Atlantic. H. affinis is (or was) so plentiful along the offshore slopes of the Banks that front Nova Scotia and the eastern part of the Gulf of Maine that many specimens were brought in for a few years subsequent to about 1875 when fishermen, long-lining for halibut, extended their operations down to depths of 350 fathoms or so. But it dropped out of sight so soon with the decline in the local halibut fishery that by 1895 it was characterized as "formerly often brought in."[90] In fact, only one specimen seems to have been reported during the past 25 years.[91] But we suspect that it would be found on the offshore slopes in undimished numbers if it were sought at the proper depth or if inquiry as to its presence were made among such of the Nova Scotian fishermen as work down the slopes of the Banks.[92]

Synonyms and References:

Chimaera affinis Brito Capello, J. Sci. math. phys. nat. Lisboa, *1* (4), 1867: 314, pl. 3, figs. 1, 1a (descr., ills. deep water off Portugal); J. Sci. math. phys. nat. Lisboa, *2*, 1870: 138 (listed, Setubal, Portugal); Günther, Cat. Fish. Brit. Mus., *8*, 1870: 350 (descr., Portugal); Guide to Study Fish., 1880: 350 (listed, coast of Portugal); Brito Capello, Cat. Peix. Portugal, 1880: 43 (listed, off Setubal, Portugal); Jordan, Rep. U. S. Comm. Fish. (1885), 1887: 800 (listed, Atlant. Coast N. Amer., deep water); Carus, Prod. Fauna Medit., *2*, 1889–1893: 529 (listed, off Portugal); Almeida and Roquette, Peices do Algarve, in Inquerito Indust. Lisboa (1889), *2*, 1892: 377 (listed, Portugal; not seen); Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 31, 509; *31*, 1895: pl. 10, figs. 32–35; also in Mem. Harv. Mus. comp. Zool., *22*, 1896: 31, 509, pl. 10, figs. 32–35 (descr., ill., range); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (*1*), 1896: 95 (descr., range); Rep. U. S. Comm. Fish. (1895), 1896: 225 (listed, C. Cod northward, and Portugal); Bull. U. S. nat. Mus., 47 (*4*), 1900: pl. 19, fig. 49 (ill. after Goode and Bean, 1895); Linton, Bull. U. S. Bur. Fish., *19*, 1901: 434 (nematode parasites); Bridge, Camb. Nat. Hist., *7*, 1904: 469 (listed, off Portugal and N. Amer., 200–1,200 fath.); Garman, Mem. Harv. Mus. comp. Zool., *40*, 1911: 91 (descr., refs., range); Seabra, Poiss. Port., 1911: 191 (listed, Portugal); Halkett, Check List Fish. Canad., 1913: 43 (listed, LaHave Bank, deep water off Nova Scotia, Gulf Stream, Portugal); Bigelow and Welsh, Bull. U. S. Bur. Fish., *40* (1), 1925: 73 (descr., ill. after Goode and Bean, 1895, range); Rey, Fauna Iberica, Peces, *1*, 1928: 666, fig. 197 (descr., ill. after Goode and Bean 1895, off Portugal); Breder, Field Bk. Mar. Fish. Atlant. Coast, 1929: 40 (ill. after Goode and Bean 1895, range); Firth, Bull. Boston Soc. nat. Hist., 61, 1931: 9–10 (photo of largest recorded specimen, color, depth, off C. Sable, Nova Scotia); Bigelow and Schroeder, Canad. Atlant. Fauna, 12f, 1934: 38 (descr., ill., range, depth); Norman, 'Discovery' Rep., *12*, 1935: 47 (cf. *C. africanus*); Nobre, Fauna Marinha Port. Vert., *1*, 1935: 407 (descr., refs., off Portugal); Bigelow and Schroeder, Bull. U. S. Bur. Fish., *48*, 1936: 326 (same specimen as in Firth 1931); Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 495 (descr., refs., range).

Chimaera plumbea Gill, Bull. philos. Soc. Wash., *2*, 1872–1880: 182 (descr., SE of LaHave Bank, Nova Scotia, 350 fath.); Bean, Proc. U. S. nat. Mus., *3*, 1880: 114 (listed, Grand Banks and Nova Scotian Banks); Goode and Bean, Rep. U. S. Comm. Fish. (1879), 1882: 788 (listed, Georges Bank); Jordan and Gilbert, Bull. U. S. nat. Mus., 16, 1883: 54 (descr., Atlant. Coast, C. Cod northward, deep water).

89. Bean's (Proc. U. S. nat. Mus., *3*, 1880: 114) report of it as *Chimaera plumbea* from the "Grand Banks" doubtless referred to the southeastern part of the Newfoundland Bank, which was commonly so-called by the Gloucester fishermen of that day. One was reported from Lat. 28°51′ N, Long. 88°18′ W, 730 fathoms, by Goode and Bean (Smithson. Contr. Knowl., *30*, 1895: 32) but unfortunately the specimen is no longer to be found; it is possible that this specimen was an *H. alberti* (p. 545).

90. Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 31; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 31.

91. Firth, Bull. Boston Soc. nat. Hist., 61, 1931: 9.

92. *H. affinis* has also been reported from Noank, Connecticut (Goode and Bean, Smithson. Contr. Knowl., *30*, 1895: 32). But the specimen in question is likely to have been brought in from offshore by some halibut fisherman who sailed out of that port.

Chimaera abbreviata Gill, Proc. U. S. nat. Mus., *6*, 1883: 254 (descr., Lat. 40°17′ N, Long. 66°58′ W, 1,290 fath.).

Psychichthys affinis Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), *2*, 1930: 33 (listed, C. Cod to Portugal); MacCoy, Bull. Boston Soc. nat. Hist., 58, 1931: 17 (same specimen as Firth 1931).

Bathyopolex abbreviatus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), *2*, 1930: 33 (listed, by ref. to Gill 1883).

Bathyopolex plumbeus Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), *2*, 1930: 33 (listed).

Chimaera monstrosa Vladykov and McKenzie, Proc. N. S. Inst. Sci., *19*, 1935: 52 (listed, Nova Scotian Banks, by ref. to Bean 1880, *Chimaera plumbea*, and Goode and Bean 1895).

Not *Chimaera monstrosa* Linnaeus 1758.

Hydrolagus alberti Bigelow and Shroeder 1951

Figure 121 α

Study Material. Immature male, 275 mm long to origin of upper caudal fin, holotype (U. S. Nat. Mus. No. 153588); male, 280 mm, and female, 275 mm, paratypes (U. S. Nat. Mus. No. 153559); all from Lat. 29°11′ N, Long. 86° 52′ W, 305 fathoms, Oregon St. 279.

Distinctive Characters. This newly discovered chimaerid is marked off from its genus mate *affinis* by its long caudal filament, its relatively much longer pectorals and by its much larger eyes. It resembles the Japanese *H. mitsukurii* closely but differs from it in having a shorter dorsal spine, longer pectorals, and a more conspicuously wavy lateral line anteriorly.

Description of holotype: Proportional dimensions in per cent of distance between snout and origin of upper caudal fin. Immature male, 275 mm long to origin of upper caudal fin (U. S. Nat. Mus., No. 153588).

Trunk: breadth 10.9; height 15.6.

Snout length: in front of eye 9.5; in front of mouth 10.5.

Eye: horizontal diameter 7.6; vertical diameter 5.8.

Mouth: breadth 5.5.

Nostrils: distance between 0.4.

Dorsal spine: length 15.3.

First dorsal fin: length of base to lowest point between dorsals 13.8.

Second dorsal fin: length of base 64.7.

Upper caudal fin:[93] length of base to last horny ray 19.3.

Pectoral fin: length 31.6; breadth 16.3.

Distance from snout to: origin of dorsal spine 24.4; 2nd dorsal 38.2; pectorals 23.2; pelvics 45.5.

Distance from origin to origin of: pectorals and pelvics 26.6.

Trunk opposite dorsal spine about as high as distance from snout to posterior margin of eye; about half as high close behind pelvics, tapering evenly thence rearward and terminating in a long filament which, when complete, is about $^2/_3$ the length

93. The point of origin of the lower caudal fin is not evident.

of body from snout to termination of caudal fin. Trunk strongly compressed laterally posterior to head, increasingly so rearward, its thickness about $^3/_4$ as great as its height opposite bases of pelvic fins.

Skin perfectly smooth on immature specimen, except closely pock-marked with many depressions of different sizes on top and on upper sides of head abreast of mouth and nostrils and toward tip of snout.

Lateral mucous canal with a short and abrupt wave opposite the anterior part of the first dorsal fin, after which there is a long low dip opposite the origin of the second dorsal fin, thence continuing nearly straight along rear part of trunk, descending at origin of caudal fin to follow out along lower edge of caudal axis; junction of cranial canal with aural canal somewhat more acute than a right angle; anterior course of cranial canal nearly straight, looping down in front of eye; jugular and oral canals running downward from suborbital as a joint canal for a short distance before separating. About 10–12 medium-size pores close in front of occipital canal; about 12 pores in area bounded by suborbital and joint oral-jugular canals; about 10 large openings along angular canal to front of snout; a single row of about 15 small pores descending parallel with oral branch and continuing in front of it; about 8–9 large openings along anterior part of suborbital canal from its descending wave to front of snout; jugular canal continued downward onto throat as a series of short slits.

Head about 21 % of length of trunk to upper origin of caudal fin. Snout conical with blunt tip. Eye oval, sloping a little rearward, its horizontal diameter about 1.3 times its vertical diameter; distance from tip of snout to front of eye about $^2/_5$ of length of head to origin of pectorals; pupil half of vertical diameter of eye; height of eye about $^2/_5$ of height of head, its length about $^1/_3$ of length of head to origin of pectorals. Gill openings nearly half as long as distance from tip of snout to front of eye; distance across throat between lower ends of gill openings about half as long as eye; fold across throat strongly marked. Exposed subdivision of nostrils crescentic on inner edge, about 1.5 times as long as broad, its length about 15 % as great as length of eye; distance from its own rear edge to free edge of upper lip about as long as its own length. Width of mouth, when closed, a little less than length of eye.

Anterior upper (vomerine) dental plates quadrate, their outer anterior outlines convex, with six radial ridges. Posterior upper (palatine) plates about 2.75 times as long as anterior plates, triangular, the posterior margin about $^2/_3$ as long as outer margin, surface lumpy, with four prominent ridges running longitudinally. Lower (mandibular) plates nearly as long as posterior upper plates, each plate with a double concavity and central ridge on inner surface, the cutting edge uneven, highest at center of mouth.

Dorsal spine about as long as distance from tip of snout to rear edge of pupil, reaching slightly beyond apex of first dorsal fin; outer part free from first dorsal fin, the rear face with two rows of low sharp thorns pointing toward base. First dorsal fin with sharp angle at apex and straight posterior margin; its base from origin of spine to bottom of interdorsal notch nearly as long as height along anterior margin of fin. Distance between first dorsal (when slightly depressed) and the first noticeable elevation

of second dorsal about $^{2}/_{5}$ as long as anterior margin of first dorsal. Second dorsal with horny rays easily distinguishable; upper margin nearly straight; height at midlength about $^{1}/_{5}$ as great as length of anterior margin of first dorsal; about equally great at rear end and slightly greater toward anterior end; posterior outline of second dorsal curving abruptly downward. No definite interspace between second dorsal and upper

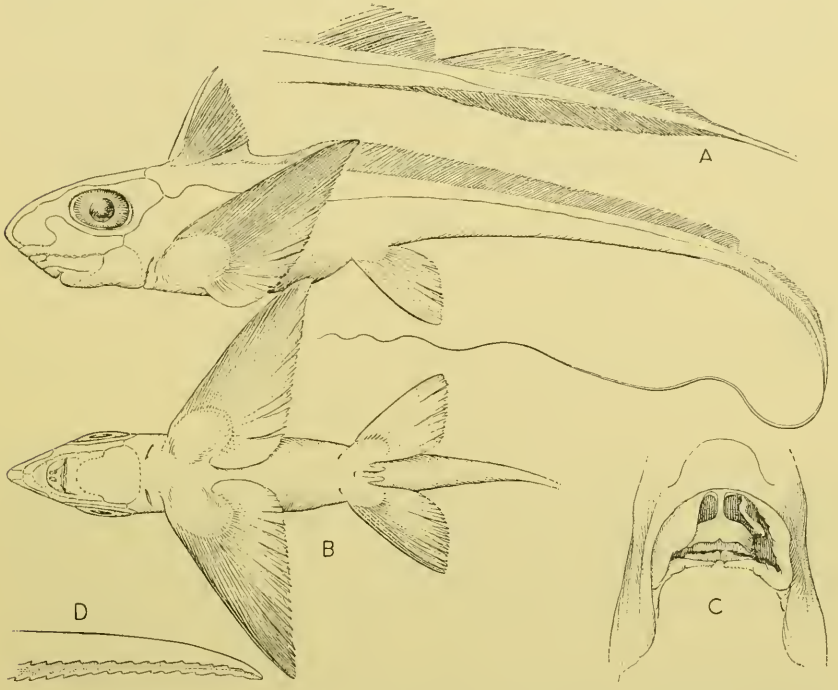

FIGURE 121α. *Hydrolagus alberti*, holotype, male, 275 mm long to origin of upper caudal fin, from offing of Pensacola, Florida, Lat. 29°11′ N, Long. 86°52′ W (U.S. Nat. Mus., No. 153588). *A* Posterior part of second dorsal fin and upper and lower caudal fins, about 1×. *B* Ventral view of head and body. *C* Mouth, with left lip folded aside to show nostrils and dental plates, about 1.3×. *D* Tip of dorsal spine, about 2.6×.

origin of caudal. Caudal lanceolate, prolonged into a long filament about $^{4}/_{5}$ as long as distance from snout to rear end of second dorsal; maximum height of caudal above axis $^{2}/_{3}$ of height of second dorsal at posterior end; its extreme length to most posterior ray about nine times as great as its height; caudal below axis about $^{4}/_{5}$ as wide as above; the most posterior rays of both upper and lower sides of caudal ending almost imperceptibly and about opposite each other; origin of lower side of caudal indefinite in position,

preceded by a low fleshy ridge distinguishable forward to a point about opposite the beginning of the last third of second dorsal fin. Pelvic fins with weakly convex anterior and distal margins, subangular outer corners and gradually rounded posterior (inner) corners; length of pelvics along anterior margin about as great as distance from tip of snout to middle of eye; origin posterior to axils of pectorals by a distance about equal to that from tip of snout to origin of pectorals. Pectoral fins about $^1/_3$ as long as distance from tip of snout to opposite rear end of second dorsal fin; tips, when laid back, extending just beyond bases of pelvics; anterior margin weakly convex; distal margin straight or slightly concave; apex sharp-pointed; inner corner broadly rounded.

Prepelvic openings present. Frontal tenaculum embedded in skin in our immature males. Claspers bifid but may develop as trifid with age. The female closely resembles the male but lacks the prepelvic openings and, of course, the frontal tenaculum.

Color. Dark brownish everywhere on head and body above and below; fins somewhat darker.

Occurrence. Nothing is known of its habits except that, like most species of chimaerids, it lives in deep water. It is known only from the offing of Pensacola, Florida, at a depth of 305 fathoms.

Reference:
Hydrolagus alberti Bigelow and Schroeder, J. Wash. Acad. Sci., *41*, 1951: 390 (descr., ills., Gulf of Mexico).

Family RHINOCHIMAERIDAE

Characters. Snout long, pointed. Lower surface of head without groove running around in front of nostrils. Dorsal spine free from first dorsal fin toward its tip. Second dorsal fin much lower than first dorsal, its upper margin nearly straight in known species. Caudal fin without definite lower anterior lobe, much broader below axis than above in adults but about equally broad above and below in young; caudal axis not bent upward. Anal fin separate from caudal in some species but not in others. Pectoral and pelvic fins about as in Chimaeridae, the former much the larger. Gums in upper jaw smooth, without transverse ridges. Surfaces of dental plates smooth in some but with a complex pattern of ridges and rounded prominences in others. Tongue with small papillae. Lateral mucous canal an open groove, its longitudinal opening a narrow slit; angular canal meeting oral canal some distance downward from point of junction of oral canal with orbital canal (Fig. 124 A). Skin of trunk entirely naked on adults, but some, when newly hatched, with a double row of strong denticles along midline of back that disappear with growth (p. 552); upper margin of caudal with a crest-like development of larger and smaller denticles in some (Fig. 122). Claspers of mature males simple, slender, rod-like, with single terminal cartilage, the tip dilated[94] and with numerous small erectile thorns pointing toward the base, the shaft smooth or with low knobs. Lower anterior surface of frontal tenaculum with ten or more hooked denticles pointing

94. For further details as to the claspers, see Garman (Bull. Mus. comp. Zool. Harv., *41*, 1904: 251).

rearward. Prepelvic tenacula blade-like, the cartilage mostly covered by thin skin with leaf-like flaps along outer anterior margin and along outer posterior margin, the front edge with a few (about 3–4) large hooks pointing toward base. Openings of prepelvic pouches nearly transverse, or slightly oblique, with inner end anterior.

Vertebral column with a great number of calcified rings surrounding notochord, plainly visible when column is laid bare by dissection. Upper unpaired rostral cartilage much longer and stouter than in other chimaeroids, directed upward at first, then bending forward abruptly to run out along upper margin of snout; flexible at point of

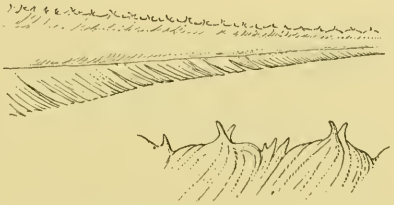

FIGURE 122. *Rhinochimaera pacifica*, male, about 600 mm long to upper origin of caudal fin, from Japan (Harv. Mus. Comp. Zool., No. 1314). Above, Portion of caudal fin, about 0.55×. Below, Upper edge of same, viewed somewhat obliquely, to show marginal denticles, about 2.7×.

curvature as well as movable at articulation with cranium; lower paired rostral cartilages much shorter, directed upward. Cranial orbits above brain case separated one from the other by a membranous partition as in Chimaeridae.[95] Cerebral hemispheres of brain well separated both from optic lobes and from olfactory bulbs.[96]

Developmental Stages. The egg capsule has broad lateral flanges and many transverse slit-like pores along either margin of the caudal extension of the embryo case on the side opposite the opercular slit.

Range and Depth. Rhinochimaerids have been recorded off Morocco and from the Irish slope in the eastern side of the North Atlantic, from the continental slope off northeastern North America between the offings of Virginia and Nova Scotia in the west; from Walfish Bay, South Africa; from Japan; probably also from the Bay of Bengal (p. 550, footnote 101). These localities are so widespread as to suggest that the family is cosmopolitan in midlatitudes of both hemispheres at the proper depths. All specimens for which the depth of capture was recorded have been taken between 375 (egg case) and 1,091 fathoms.

Genera. The few known rhinochimaerids fall into two divisions: (A) with an anal fin separate from caudal, and (B) without separate anal fin. The first of these cate-

95. See Garman (Bull. Mus. comp. Zool. Harv., *41*, 1904: pl. 1, fig. 2) for illustrations of the skeleton.
96. See Garman (Bull. Mus. comp. Zool. Harv., *41*, 1904: pl. 4) for illustrations of the brain of *Rhinochimaera*.

gories is represented by a single species, *pinnata* Schnakenbeck 1931[97] from Walfish Bay, South Africa. This species was placed by its describer in the genus *Harriotta* Goode and Bean 1886, but we have proposed the genus *Neoharriotta*[98] for it because of its separate anal fin. The members of the second category (without separate anal fin) have commonly been distributed between two genera, *Rhinochimaera* Garman 1901 and *Harriotta* Goode and Bean 1886, the former with smooth dental plates and with a series of large widely spaced denticles along the upper margin of the caudal, the latter with ridges and knobs (tritors) on the dental plates but without denticles along the margin of the caudal. From an examination of specimens of each, we judge that these differences are sufficient for generic separation.[99]

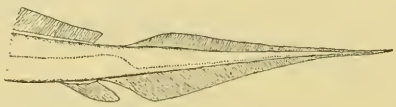

FIGURE 123. *Neoharriotta pinnata*, mature male, to show anal fin; after Schnakenbeck.

Key to Genera

1a. With a separate anal fin (Fig. 123). *Neoharriotta* Bigelow and Schroeder[100] 1950. Equatorial West Africa and Walfish Bay.

1b. Without separate anal fin.

2a. Surfaces of dental plates with ridges and rounded knobs (tritors); upper margin of caudal without denticles. *Harriotta* Goode and Bean 1886, p. 550.

2b. Surfaces of dental plates smooth or nearly so, without evident ridges or knobs (tritors); upper margin of caudal armed with a series of large denticles (Fig. 122), many of them with double cusps. *Rhinochimaera* Garman 1901.[101] Japan and Northeast Atlantic; perhaps also Bay of Bengal.

Genus *Harriotta* Goode and Bean 1886, 1895

Harriotta Goode and Bean, Proc. biol. Soc. Wash., *3*, 1886: 104, "a long-rostrated chimaeroid fish," without further description and without a species named; Proc. U. S. nat. Mus., *17*, 1895: 472; Smithson. Contr.

97. Mitt. zool. Mus. Hamburg, *44*, 1931: 39; Poll, Résult. Sci. Exped. oceanogr. Belge Côt. Afr. Atlant. (1948–49), 1951: 144–149.
98. Bigelow and Schroeder, Bull. Mus. comp. Zool. Harv., *103*, 1950: 406.
99. We have at hand an excellent specimen of *Rhinochimaera pacifica* (Mitsukuri) 1895.
100. Bull. Mus. comp. Zool. Harv., *103*, 1950: 406. Only one species is known, *pinnata* Schnakenbeck (Mitt. zool. Mus. Hamburg, *44*, 1931: 39, fig. 6, 40), from deep water.
101. Proc. New Engl. zool. Club, *2*, 1901: 75. Two species are known: *R. pacifica* (Mitsukuri) 1895 (Zool. Mag. Tokyo, *7*, 1895: 97, pl. 16), from Japan; and *R. atlantica* Holt and Byrne 1909 (Ann. Mag. nat. Hist., [8] *3*, 1909: 279; Fish. Ireland Sci. Invest. [1908], 4, 1910: 18, pl. 3), from the Irish Atlantic slope. An egg case from the Bay of Bengal, 561 fathoms, reported tentatively by Alcock and Wood-Mason (Ann. Mag. nat. Hist., [6] *8*, 1891: 21–22) as *Callorhynchus*(?) and subsequently named *C. indicus* by Garman (Mem. Harv. Mus. comp. Zool., *24*, 1899: 21) seems more likely to have belonged to some rhinochimaerid, both because of its general appearance and on geographic grounds, *Callorhinchus* not being known to occur anywhere north of the equator. But it may have been either a *Rhinochimaera* or a *Harriotta*, so far as we can judge from the illustration.

Knowl., *30*, 1895: 32; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 32; type species, *H. raleighana* Goode and Bean. Continental slope of northeastern United States, between offings of Virginia and New Jersey, 707–1,081 fathoms.

Generic Synonym:

Anteliochimaera Tanaka, J. Coll. Sci. Tokyo, *27* (8), 1909: 7; type and only included species, *A. chaetirhamphus* Tanaka; Japan.[102]

Generic Characters. No separate anal fin. Upper margin of caudal fin without denticles. Dental plates with more or less prominent grinding ridges and knobs (tritors). Characters otherwise those of the family.

Range. Long-nosed chimaeroids, referable to *Harriotta* by the smoothness of the upper margin of the caudal, by the nature of the dental plates, and by the absence of a separate anal fin, are known only from the continental slope off the middle Atlantic States and off Nova Scotia in the western Atlantic; near the Canaries and west of Scotland in the eastern Atlantic; from Japan; probably also off Lower California.

Species. H. raleighana Goode and Bean 1895 from the two sides of the North Atlantic and *H. chaetirhamphus* (Tanaka) 1909 of Japan resemble one another so closely that they have been united recently under the older of these two names.[103] Since we have not seen any Japanese specimens, we are not in a position to judge whether they are in fact identical. The rhinochimaerid described from off Lower California by Townsend and Nichols[104] as *H. curtis-jamesi* also resembles *H. raleighana* so closely that the illustration of it does not suggest any significant difference. But the nature of its dental plates is not known in detail. And an empty egg capsule from the Bay of Bengal, reported as *Callorhynchus(?)*, seems rather to have belonged to some rhinochimaeroid, perhaps to *Harriotta* (p. 550, footnote 101).

Harriotta raleighana Goode and Bean 1895

Long-nosed Chimaera

Figures 124, 125, 126

Study Material. Juvenile male, about 485 mm long to posterior rays of upper side of caudal fin, from continental slope off Virginia at 781 fathoms, Albatross St. 273 (Oct. 25, 1886), in U. S. National Museum; also three maturing males, 535–558 mm to upper origin of caudal, and one newly hatched female, 112 mm, trawled on the continental slope off southern Nova Scotia and on the southeastern slope of Georges Bank at 400–460 fathoms,[105] in Harvard Museum of Comparative Zoology; an empty egg capsule, probably of this species, from off southern New England, Lat. 39° 47′ N, Long. 70° 31′ W, at 963 fathoms, Albatross St. 2216 (August 22, 1884), in U. S.

102. Referred here to *Harriotta* rather than to *Rhinochimaera* because the upper anterior dental plates and also the lower plates are described (we have not seen it) as having ridges (tritors), the latter also with grinding prominences.
103. Fowler, Bull. U. S. nat. Mus., 100 (*13*), 1941: 504–505.
104. Bull. Amer. Mus. nat. Hist., *52*, 1925: 6, fig. 2.
105. Lat. 41°25′ N, Long. 65°54′ W, 400–450 fath.; Lat. 42°39′ N, Long. 64°04′ W, 440–460 fath.; Lat. 42°40′ N, Long. 64°00′ W, 440–450 fath., trawled by the research vessel Caryn in July 1949.

National Museum; fragments of another case, from continental slope off southern Nova Scotia, Lat. 42° 38′ N, Long. 64° 05′ W, at 450 fathoms, July 17, 1949, trawled by the research vessel CARYN, in Harvard Museum of Comparative Zoology.

Distinctive Characters. This species is given so distinctive an appearance by its long pointed snout that it could hardly be confused with any other Atlantic chimaeroid except *Neoharriotta pinnata* from west central and southwestern Africa or *Rhinochimaera atlantica*, known only from the Irish Atlantic slope. It is sharply set apart from the first of these by its lack of a separate anal fin, from the second by the smoothness of the upper margin of its caudal fin.[106]

Description. Proportional dimensions in per cent of distance between snout and origin of upper caudal fin. Males, 545 and 558 mm long to origin of upper caudal, from Lat. 42° 40′ N, Long. 64° 00′ W and vicinity (Harv. Mus. Comp. Zool., Nos. 37023 and 37022, respectively).

Trunk: breadth 8.6, 9.0; height 13.5, 13.7.
Snout length in front of: eye 28.1, 28.7; mouth 29.4, 26.4.
Eye: horizontal diameter 5.7, 5.0; vertical diameter 4.0, 3.2.
Mouth: breadth 4.4, 4.0
Nostrils: distance between 1.8, 1.8.
Dorsal spine: length 18.2, 18.5.
First dorsal fin: length of base 10.6, 11.1.
Second dorsal fin: length of base 33.8, 32.6.
Upper caudal fin: length of base to last horny ray 30.3, 30.1.
Lower candal fin: length of base to last horny ray 42.5, 38.2.
Pectoral fin: length 25.9, 26.0; breadth 13.8, 15.2.
Distance from snout to: origin of dorsal spine 42.2, 41.8; 2nd dorsal 57.7, 57.5; pectoral 38.8, 40.2; pelvics 65.2, 61.8.
Interspace between: 1st and 2nd dorsals 5.9, 4.5; 2nd dorsal and caudal 8.8, 8.0.
Distance from origin to origin of: pectorals and pelvics 28.6, 27.7; pelvics and lower caudal fin 27.9, 27.7.

Trunk tapering evenly rearward; strongly compressed posterior to origins of pectorals; about half as thick as high at level of origin of pectorals, its sides flat or weakly convex; its greatest height, opposite dorsal spine, about $^3/_4$ (78 %) as great as distance from front of eyes to origin of pectorals, about $^3/_4$ that high close behind pelvics.

Skin with 4–6 sharp conical denticles in a double row on top of head; also at hatching a double row in interspaces between first and second dorsals and between second dorsal and caudal, these disappearing so early in growth that no trace of them is evident on specimens 485 mm or larger.

Mucous canals open, as narrow slits; lateral canal irregularly wavy, descending opposite upper origin of caudal to follow out along lower margin of caudal axis as in

106. The upper margin of the caudal of *R. atlantica* has a series of denticles. For description, see Holt and Byrne (Fish. Ireland Sci. Invest. [1908], 4, 1910: 18, pl. 3).

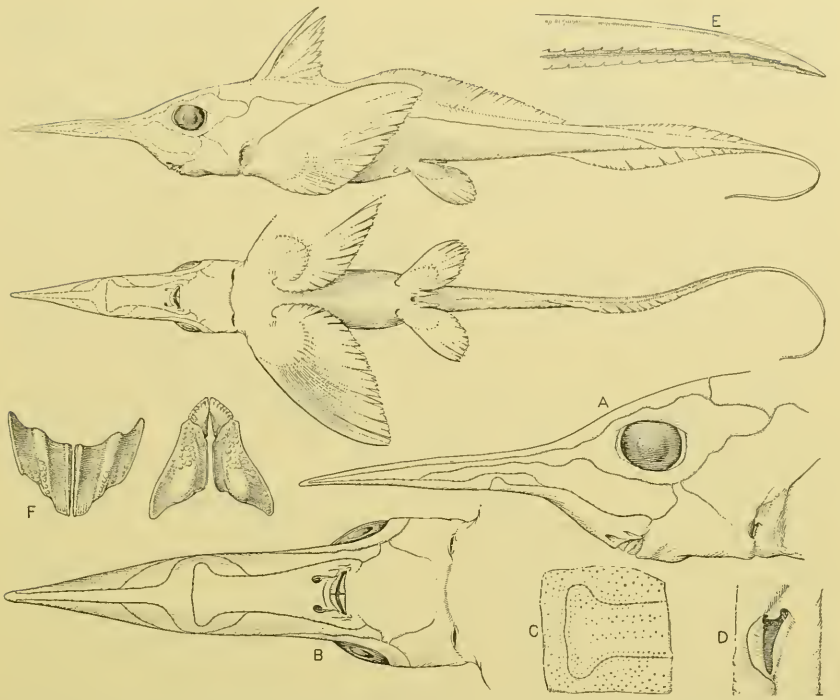

FIGURE 124. *Harriotta raleighana*, juvenile male, about 485 mm long to upper origin of caudal, from off Virginia, 781 fathoms (U. S. Nat. Mus., No. 38200). *A* Side view of head, to larger scale, to show mucous canals, about 0.7×. *B* Ventral view of same, about 0.7×. *C* Region enclosed in anterior loop of angular mucous canal to show distribution of mucous pores, about natural size. *D* Left-hand gill opening with anterior margin rolled forward, about 1.7×. *E* Side view of terminal part of dorsal spine, about 2.6×. *F* Upper dental plate (right) and lower dental plate (left), about 1.3×.

Chimaera; junction of cranial canal with aural canal about a right angle; cranial canal of each side wavy over eye, thence nearly straight to tip of snout; suborbital canals also wavy close in front of eye, but straight thence forward; jugular canal and oral canal arising either jointly from orbital canal (Fig. 125 *A*), or separately, with a short interspace; angular (maxillary) canal joining suborbital about $^2/_3$ of distance from level of front of eye toward tip of snout; anterior part of suborbital canals and angulars with their interconnecting loop marked by series of rounded openings. Skin on lower side of snout with numerous conspicuous mucous pores in region of angular (maxillary) canal-loop.

Head about $^2/_5$ (43 %) of total length of trunk to lower origin of caudal fin.

Snout narrow-triangular, more or less flattened above and below, wider transversely than vertically, its lateral margins converging to slender tip; soft on small specimens, stiff on larger, especially toward tip; movable in the vertical plane at base and also about $^1/_5$ of distance out along its length where unpaired rostral cartilage is flexible (p. 519); curving upward slightly in large females, abruptly so along anterior $^1/_5$–$^1/_4$ in mature males; tip smooth in females, but with a double series of low and hard rounded knobs at maturity in males, their arrangement as shown in Fig. 125. Eye about $^1/_3$ of vertical height of head at center of eye; its length about $^1/_7$ of length of head from snout to origin of pectorals. Gill openings about half as long as eye; distance across throat between inner ends of gill openings about as long as eye, marked by an indistinct furrow. Exposed division of nostril oval, a little longer than broad, about 8–10 % as long as eye; distance from its rear edge to rear edge of upper lip about twice as great as its own length. Width of mouth, when closed, about $^2/_3$ as great as length of eye. Tongue with a few fleshy swellings and many smaller papillae of various sizes.

Dental plates smooth at hatching, a series of grinding surfaces developing soon thereafter. Upper anterior (vomerine) plates cupped from front to rear, their outer anterior margins nearly straight or weakly convex with 7–9 rounded knobs or short radial ridges that may be entirely obliterated by maturity in some specimens;[107] inner margins smooth or with 2 or 3 low knobs. Posterior upper (palatine) plates about 2.5 times as long as anterior plates, subtriangular, about twice as long as broad; anterior part and outer margin with variable numbers of small rounded knobs of various sizes; inner posterior part with a single large swelling foreshadowed on some small specimens by a series of about eight transverse ridges.[108] Lower (mandibular) plates about as long as palatine plates, the free edges more or less irregular, probably depending on wear; anterior and outer margins with irregular (single or double) series of small rounded knobs that persist to maturity on some specimens but may be partially reduced to indistinct radial ridges on others even at an early stage in growth;[109] also a more or less prominent medial longitudinal ridge foreshadowed on at least some small specimens by a series of transverse ridges.

Dorsal spine about over gill openings, about half as long as distance from tip of snout to rear edge of eye, reaching a little beyond apex of first dorsal fin; its outer $^1/_2$–$^2/_3$ free from fin, compressed laterally, with rear face somewhat channelled longitudinally and having two rows of serrations of characteristic form (Fig. 124E). First dorsal fin triangular with acute apex, its posterior margin nearly straight; base (origin to midpoint of interdorsal notch) about $^4/_5$ as long as anterior margin. First and second dorsal fins connected at bottom of notch by a low fold of skin, without definite interspace. Second dorsal rising gradually to maximum height a little anterior to level of tips of pectorals

107. The margins of the upper anterior plates have these knobs on one mature male examined by us, but they are pictured as entirely smooth for a large female (Roule and Angel, Result. Camp. sci. Monaco, *86*, 1933: pl. 4, fig. 34c).

108. So pictured by Garman (Bull. Mus. comp. Zool. Harv., *41*, 1904: pl. 5, fig. 4).

109. Marginal knobs are well developed on a mature male that we have seen and on a large female also (Roule and Angel, Result. Camp. sci. Monaco, 86, 1933: pl. 4, fig. 34d), but they show only faintly on a smaller male (Fig. 123).

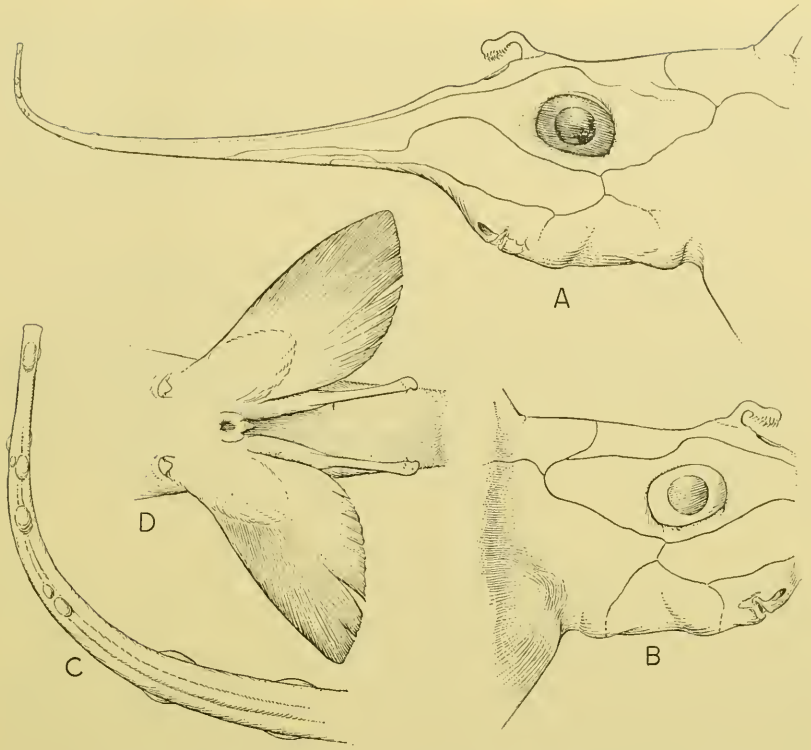

FIGURE 125. *Harriotta raleighana*, male, 558 mm long to upper origin of caudal fin, from Lat. 42°40′ N, Long. 64°00′ W, 440–460 fathoms (Harv. Mus. Comp. Zool., No. 37022). *A* Left-hand side of head. *B* Right-hand side of head. *C* Tip of snout, about 2.3×. *D* Pelvic fins and claspers.

(when these are laid back), thence decreasing in height rearward with straight upper margin; rear termination abruptly truncate; first sensible elevation of second dorsal posterior to front of dorsal spine by a distance a little less than half of distance from rear of eye to tip of snout; its maximum height about $^4/_5$ as great as length of eye; its rear end about over lower origin of caudal. Second dorsal separated from upper origin of caudal by an interspace about 1.5 times as long as eye. Caudal lanceolate, tapering to narrow tip prolonged as a slender band-like filament; its total length from lower origin to filamentous tip about as great at maturity as distance from rear end of second dorsal to front margin of eye, or greater; rayed portion of caudal fin about twice as high below caudal axis as above on small specimens; about three times as high below axis as above on larger ones; maximum height of lower side of caudal about as great as height of axis at same point at hatching; about three times at maturity; height of upper side about $^1/_3$

as great as height of axis at hatching; about $^2/_3$ at maturity. Pelvic fins pointed at hatching but rounded posteriorly on larger specimens, about $^1/_3$ as long as distance from tip of snout to rear margin of eye, or about as long as first dorsal. Pectorals about 1.3 times as long as distance from tip of snout to rear margin of eye at hatching, about equal to that distance on half-grown specimens, about 80 % on large; their tips (when laid back) reaching about $^2/_3$ of distance along outer margin of pelvics at hatching, about to origin of pelvics at maturity; anterior margin rather strongly convex, apex subangular, distal margin weakly convex, posterior corner broadly rounded; margin curving sharply inward and rearward at axil.

Secondary Sexual Characters of Male. Frontal tenaculum seemingly not formed on males until about $^1/_3$ grown,[110] well developed at maturity; curved strongly downward; tip swollen in usual chimaeroid form; armed below with strong thorns directed rearward. Openings of prepelvic pouches nearly transverse or slightly oblique, with inner ends a little anterior; tenacula with about four strong sharp hooks directed inward and forward along inner anterior edge of blade. Claspers rod-like, tapering a little; tip somewhat swollen; their extremities falling a little short of extremities of pelvic fins on largest specimen seen; tips armed with a few sharp thorns directed toward base; shaft also studded with low rounded knobs in one specimen, apparently the most nearly mature.[111]

Color. Fresh-caught males, seen by us, uniformly chocolate brown below as well as above; mucous canals showing as pale lines; dorsal, pelvic and pectoral fins widely edged with darker brown, the caudal narrowly so; dorsal spine, shafts of claspers and prepelvic tenaculum whitish. Fresh-caught female described[112] as of same chocolate hue but somewhat paler below eyes, above insertions of pectorals, and along flanks; mouth and area between bases of pectorals bluish gray; pelvics black; iris pale green; sclerotic membrane blackish brown or black. Newborn female pale bluish gray above and below, darkest over abdomen; rayed portions of pectorals and pelvics black, their fleshy bases whitish; dorsals gray basally, edged with sooty; dorsal spine sooty.

Size. The length at hatching is about 100 mm to upper origin of caudal fin;[113] males mature at a length of about 540 mm to upper origin of caudal fin (about 730 mm to rearmost rays of upper side of caudal, or about 810 mm to tip of caudal filament). The largest female seen was about 637 mm to upper origin of caudal fin (about 990 mm to tip of caudal filament).

Egg Capsule. On an empty egg capsule about 165 mm long, probably of this species,[114] the embryo case is more strongly convex on one side than on the other, of the

110. There is no trace of it on one 300 mm long to posterior ray of upper side of caudal fin.
111. So judged because the basal gland is more swollen than on the other two males examined.
112. Roule and Angel, Result. Camp. sci. Monaco, *86*, 1933: 77.
113. A specimen only 102 mm in total length, pictured by Goode and Bean (Smithson. Contr. Knowl., *31*, 1895: pl. 11, fig. 29), appears to have been taken from the egg capsule and somewhat mutilated (Garman, Bull. Mus. comp. Zool. Harv., *41*, 1904: 266). It is now in fragmentary condition.
114. The identity of this egg capsule seems well established because (a) it closely resembles an egg capsule that is almost certainly that of the Japanese *Rhinochimaera pacifica* (Dean, J. Coll. Sci. Tokyo, *19* [4], 1904: 18–19, pl. 2, figs. 12–12b; Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 38, fig. 23), and because (b) *H. raleighana*

shape shown in Fig. 126; the lateral flanges are thin, each with 51–52 narrow transverse ribs; the lateral extensions of the open opercular slit still have remnants of interlocking hooklets. The caudal pores are slit-like, about 125 on each side, opening on the surface opposite the opercular slit. The caudal extension of the embryo case has a longitudinal groove on the opercular surface. The membrane is thin, the opercular surface of the anterior part of the embryo case with a few hairs. The embryo case is nearly black, the flanges pale amber.[115]

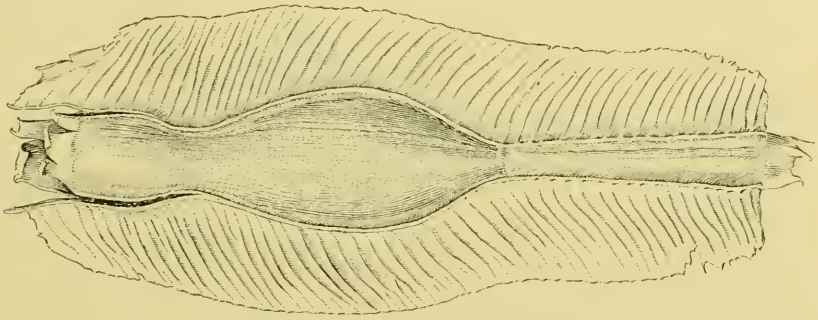

FIGURE 126. Empty egg capsule, about 165 mm long, probably of *Harriotta raleighana*, from Lat. 39°47′ N, Long. 70°31′ W, 963 fathoms (U. S. Nat. Mus., No. 35603), viewed from side with opercular opening.

Habits. Evidently this is strictly a deep water species, all the specimens recorded having been trawled at depths ranging from 375 fathoms (686 m) for the empty egg case down to 1,422 fathoms (2,603 m). The captures of a newborn specimen on June 20, 1949 and of another that was just born or torn from the egg capsule[116] show that its young are hatched in summer, though perhaps at other seasons also. Nothing else is known of its habits.

Range. Both sides of the North Atlantic; continental slope of mid-Atlantic and North Atlantic United States and Nova Scotia in the west; near the Canaries (1 specimen) and west of Scotland (2 specimens) in the east.

Occurrence in the Western Atlantic. Only nine specimens have been taken in the western Atlantic: one off Chesapeake Bay, three off New York and southern New England, two on the southeastern slope of Georges Bank, two off southern Nova Scotia, and one off Halifax, Nova Scotia.[117] Empty egg capsules, apparently of this species, have

is the only known representative in the western North Atlantic of either of the chimaeroid families (Rhinochimaeridae, Callorhinchidae) that have egg capsules with broad lateral flanges with many transverse ridges.

115. A similar egg capsule from off Halifax, Nova Scotia, has been described and pictured as *Harriotta* (?) by Dean (Publ. Carneg. Instn., 32, 1906: 36, fig. 19).

116. ALBATROSS Sta. 2210, August 21, 1884.

117. Lat. 36°45′ N, Long. 74°29′ W; Lat. 39°12′ N, Long. 72°03′ W; Lat. 39°38′ N, Long. 71°19′ W; Lat. 39°45′ N, Long. 70°31′ W; Lat. 41°25′ N, Long. 65°54′ W; Lat. 42°39′ N, Long. 64°04′ W; Lat. 42°40′ N, Long. 64°00′ W; and Lat. 42°37′ N, Long. 63°27′ W.

been trawled off southern New England at 963 fathoms, off southern Nova Scotia at 450 fathoms, and off Halifax, Nova Scotia at 375 fathoms.

References:

Harriotta raleighana Goode and Bean, Proc. U. S. nat. Mus., *17*, 1895: 472, pl. 19 (descr., ills., depth, off mid-Atlant. U. S.); Smithson. Contr. Knowl., *30*, 1895: 33; *31*, 1895: pl. 11, figs. 37–40; also, Mem. Harv. Mus. comp. Zool., *22*, 1896: 33, pl. 11, figs. 37–40 (descr., ills.); Anon., Amer. Nat., *29*, 1895: 281, pl. 19 (listed, off mid-Atlant. U. S., by ref. to Goode and Bean 1895; ills. after Goode and Bean 1895); Jordan and Evermann, Bull. U. S. nat. Mus., 47 (1), 1896: 96 (descr., same specimens as in Goode and Bean 1895); Rep. U. S. Comm. Fish. (1895), 1896: 226 (listed, off Atlant. Coast, U. S.); Bull. U. S. nat. Mus., 47 (4), 1900: pl. 19, fig. 42 (ill. after Goode and Bean 1895); Garman, Bull. Mus. comp. Zool. Harv., *41*, 1904: 263, pl. 2, figs. 3–5, pl. 4, fig. 1, pl. 5, figs. 3–9 (descr., ills. mucous canals, skin, dental plates, same specimens as in Goode and Bean 1895); Dean, Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 7 (listed, N. Atlant.), 121, 122, 125, figs. 94A, B, 96, 107–109 (ills., dental plates); Bean and Weed, Proc. U. S. nat. Mus., *37*, 1910: 662, pl. 38 (diagn., ills. after Goode and Bean 1895; N. Atlant.); Byrne, Fish. Ireland Sci. Invest. (1908), 4, 1910; 20 (meas., cf. *Rhinochimaera atlantica* Holt and Byrne); Garman, Mem. Harv. Mus. comp. Zool., *40*, 1911: 95 (refs., descr., depth, west. N. Atlant.); Koefoed, Rep. Sars N. Atlantic Deep Sea Exped. (1910), *4* (1), 1927: 29, pl. 3, figs. 1, 2 (descr., meas., ills., depths, near Canaries and W. of Scotland); Jordan, Evermann and Clark, Rep. U. S. Comm. Fish. (1928), *2*, 1930: 33 (listed, deep water off N. Atlant. U. S.); Schnakenbeck, Mitt. zool. Mus. Hamburg (1929), *44*, 1931: 38, 41 (cf. *H. pinnata* Schnakenbeck); Roule and Angel, Result. Camp. sci. Monaco, *86*, 1933: 75, pl. 4, figs. 34–34e (descr., meas., ills., depth, off Halifax, Nova Scotia); Fowler, Bull. Amer. Mus. nat. Hist., *70* (1), 1936: 145 (descr., ill. after Goode and Bean, Atlant.); Bull. U. S. nat. Mus., 100 (*13*), 1941: 504 (refs., descr.; considered identical with *Rhinochimaera atlantica* Holt and Byrne [Ann. Mag. nat. Hist., (8) *3*, 1909: 279], Irish Atlant. slope, and *H. chaetirhamphus* [Tanaka] [J. Coll. Sci. Tokyo, *27*, 1909: 7, pl. 1], Japan); Marcelet, Bull. Inst. Océanogr. Monaco, 817, 1942: 3 (sp. gr. of oil).

Family CALLORHINCHIDAE

Characters. Snout rounded, with a curious flexible hoe-shaped proboscis, the proximal part much compressed laterally and extending forward, the terminal part bent downward as a thin transverse leaf-like appendage that is capable of spreading widely sidewise or of folding rearward along its midline (Fig. 127); upper edge of proboscis supported by the upper unpaired rostral cartilage, the lower edge by the two smaller and lower paired rostral cartilages. Second dorsal fin separated widely from first dorsal. Caudal fin much wider below its axis than above, with distinct lower anterior lobe but without terminal filament; caudal axis bent somewhat upward, about at level of origin of caudal fin. Anal fin separated from caudal fin by a deep narrow notch. Gums in upper jaw with a series of transverse ridges. Margins of dental plates without radial ridges. Claspers of males rod-like, with single long terminal cartilage, their tips not dilated. Frontal tenaculum well developed on half-grown males and larger but not visible on very young. Prepelvic tenacula more complex in structure than in other chimaeroids, spoon-shaped, the blade armed along inner face with denticles having several cusps; skin covering it thin, expanded on outer side as two frill-like lobes; a globular gland near its base on inner side, opening to exterior by a short tube.[118] Openings of prepelvic pouches longitudinal or nearly so, present on females though smaller

118. For a more detailed account, see Leigh-Sharpe (J. Morph., *36*, 1922: 208).

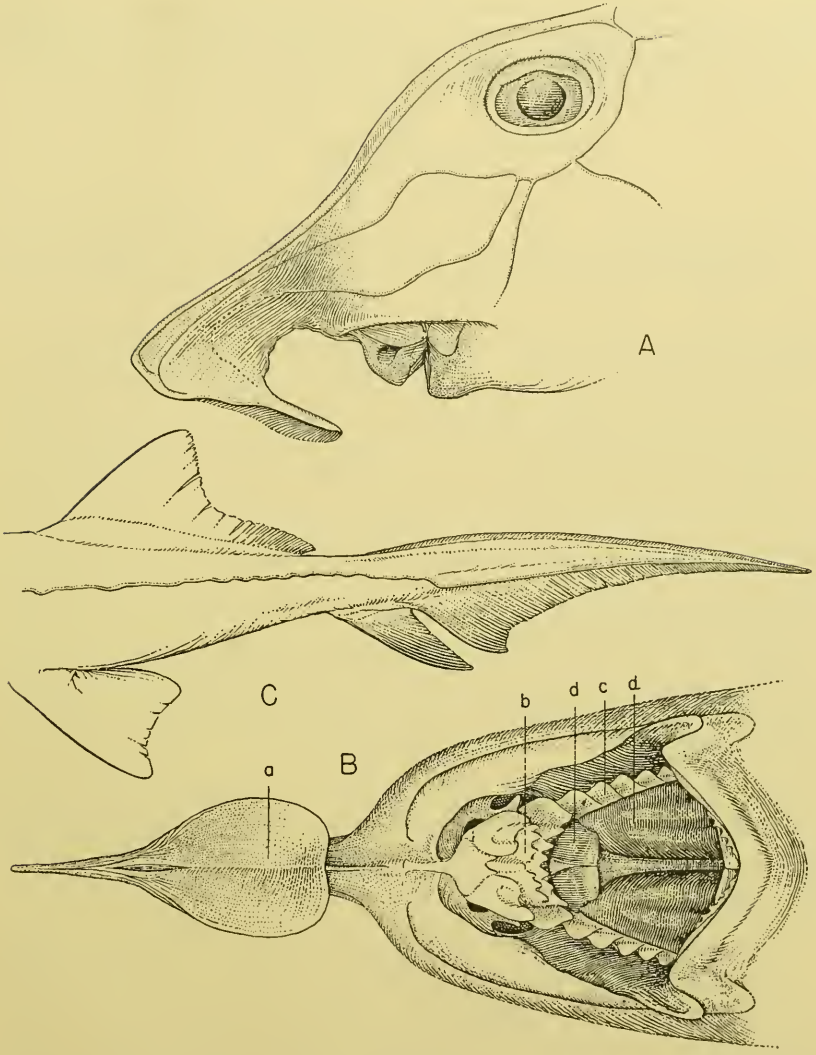

FIGURE 127. *Callorhinchus milii*, 290 mm long to upper origin of caudal fin, total length 430 mm, from Hobarttown, Tasmania (Harv. Mus. Comp. Zool., No. 142). *A* Side view of head, to show rostral appendage and mucous canals, about 1.2×. *B* Ventral view of anterior part of head of same, with mouth opened to show rostral appendage (a), papillae (b), transverse ridges on upper gums (c), also upper dental plates (d), about 1.5×. *C* Side view of posterior part of trunk of same, to show second dorsal, caudal and anal fins, about 0.6×.

than on males.[119] Vertebral column without calcified rings surrounding notochord. Cranial orbits level with brain cavity, each separated from the latter by a membranous partition; cerebral hemispheres much nearer to optic lobes than to olfactory bulbs.[120]

Genera. Only one modern genus is known, *Callorhinchus* Lacépède 1798.

Genus *Callorhinchus* Lacépède 1798[121]

Elephant Fish

Callorhinchus Lacépède, Hist. Nat. Poiss., 4° edit., in Buffon, Hist. Nat., *1*, 1798: 400, footnote; emended spelling for *Callorynchus* Gronovius (Mus. Ichthyol., *1*, 1754: 59, no. 130, pl. 4, figs. 1, 2); by ref. to Gronovius; type species, *Chimaera callorynchus* Linnaeus (Syst. Nat., *1*, 1758: 236). Type locality "in mare Aethiopico."

Generic Synonyms:

Callorynchus Gronovius, Mus. Ichthyol., *1*, 1754: 59, no. 130, pl. 4, figs. 1, 2; excellent descr. and ill., but no species named; Mus. Ichthyol., *2*, 1756: 52; not available because pre-Linnaean.

Callorynchus Linnaeus, Syst. Nat., 1756: 42; by ref. to Gronovius; not available because prior to tenth edition of Systema Naturae (1758).

Callorynchus Gronovius, Zoophyl., *1*, 1763: 31; for Callorynchus pinna dorsi secunda triqueta ....; not available because non-binomial.

La Chimere antarctique, Lacépède, Hist. Nat. Poiss., 4° edit., in Buffon, Hist. Nat., *1*, 1798: 400; equals *Chimaera callorynchus* Linnaeus 1758.

Callorhincus Duméril, Zool. Analyt., 1806: 104; emended spelling for *Callorynchus* Gronovius 1754, 1763, by ref. to Gronovius.

Callorhynchus Cuvier, Règne Anim., *2*, 1829: 382; type species, *Chimaera callorynchus* Linnaeus 1758; also many subsequent authors.

Callorhyncus Fleming, Phil. Zool., *2*, 1822: 380; type and only included species, *C. antarcticus* Fleming, equals *Chimaera callorynchus* Linnaeus 1758.

Callorinchus Griffith and Smith, in Cuvier, Anim. Kingd., *10*, 1834: 97 footnote; no species named; probably emended spelling for *Callorynchus* Gronovius 1754, 1763 and Cuvier 1829.

Callirhynchus Agassiz, Nomencl. Zool. Index, 1846: 60; emended spelling for *Callorynchus* Gronovius 1754, by ref. to Gronovius.

Not *Callorynchus* Gronovius, Acta Helvet., *7*, 1772: 49; probably equals *Chimaera* Linnaeus 1758; see p. 524, footnote 41.

Generic Characters. Separate anal fin much higher than long, close to lower origin of caudal, its apex rounded. Dorsal spine free along its outer $^1/_3$–$^1/_2$, its free posterior

119. They are represented by short slits on a female *C. callorynchus* from Chile that we have seen.

120. For illustrations of the brain, see especially Garman (Bull. Mus. comp. Zool. Harv., *41*, 1904: pl. 15, figs. 4, 5).

121. The generic name of the Elephant Fishes has usually been spelled *Callorhynchus* by reference to Gronovius, 1754 (Mus. Ichthyol., *1*, 1754: 59, no. 130, pl. 4, figs. 1, 2) and to Gronovius, 1763 (Zoophyl., *1*, 1763: 31). But the earlier of these two accounts by him (one of the best that has appeared and with one of the most accurate illustrations) was pre-Linnaean, while the later one was not binomial and hence has been ruled unavailable by the International Commission on Zoological Nomenclature (Opin. 89, Smithson. misc. Coll., *73* [3], 1925: 27, reversing Opin. 20). The earliest strictly binomial application of *Callorynchus*, again by Gronovius in a paper that seems to have been overlooked (Acta Helvet., *7*, 1772: 49), referred not to an Elephant Fish but to one of the Chimaeridae, probably to a *Chimaera*. Hence, strictly speaking, *Callorynchus* Gronovius 1772 must be relegated to the probable synonymy of *Chimaera* Linnaeus 1758. But the International Rules of Zoological Nomenclature do permit the use of *Callorhinchus* Lacépède 1798 (Hist. Nat. Poiss., 4° edit., in Buffon, Hist. Nat., *1*, 1798: 400, footnote) for the Elephant Fish; this, by direct reference, was an altered spelling for *Callorynchus* Gronovius 1754. We may point out that a change in the generic name of the Elephant Fishes could only result in endless confusion, for they have passed as *Callorhynchus* in all of the more important works on the Holocephali that have appeared during the 19th and 20th centuries as well as in numerous more general texts on the zoology of vertebrates.

surface grooved longitudinally, each margin with a row of small sharp thorns curving downward. First dorsal fin triangular with acute apex. Separation between first and second dorsals nearly as long as pectoral fin. Second dorsal subtriangular anteriorly, its posterior portion lower and sloping rearward, separated from origin of caudal fin by a considerable interspace. Caudal fin about as long as pectoral, only about $^1/_{10}$–$^1/_{12}$ as wide above caudal axis as below and tapering gradually to narrow tip. Pectorals and pelvics shaped much as in the Chimaeridae; pectorals much larger than pelvics and longer than head, omitting proboscis.

Horizontal diameter of eye only about $^1/_5$ as long as head, omitting proboscis. Roof of mouth sculptured in complex pattern close in front of anterior plates, a series of short and stiff transverse folds bordering anterior dental plates and anterior half of posterior plates on each side. Tongue close-set with small papillae.

Margins of dental plates more or less rounded. Anterior upper plates subtriangular (apex forward), strongly cupped, with one broadly rounded longitudinal ridge (tritor) along inner margin. Posterior upper plates much larger, their anterior part nearly flat transversely, posterior part somewhat cupped, either with two narrow longitudinal ridges (tritors) or with one broader ridge, with more or less distinctly notched anterior end. Lower dental plates also either with one broad longitudinal ridge or with two narrower ridges.[122]

Denticles in a double row on midbelt of back from close in front of dorsal spine to level of front of eye, in U-shaped pattern anteriorly; small specimens with a double series also, extending part way from first dorsal toward second dorsal; denticles also in interspace between second dorsal and caudal, these tending to disappear with growth; skin of trunk wholly naked elsewhere; no denticles on claspers; but lower anterior surface of frontal tenaculum with recurved thorns, and anterior convex face of prepelvic tenacula with a number of large complex denticles, each with several cusps.[123]

Lateral mucous canal tubular after hatching; jugular, oral, and angular mucous canals all meeting suborbital canal separately; suborbital and cranial canals extending out along proboscis, the pair on each side joining near tip; angular canals also running out along proboscis lower down (Fig. 127A). A well marked furrow below front of head, running from beside rear end of outer part of upper lip around in front of each nostril, but interrupted between nostrils.

Egg Capsules. The egg capsules,[124] described as 170–420 mm long, are smooth on one side, furry on the other. A great number of hair-like filaments dot the lateral flanges densely though irregularly and extend out beyond the margins to form a more

122. See Norman (Discovery Rep., 16, 1937: 35) for variations in the grinding ridges in *C. callorynchus*.

123. For more detailed accounts and illustrations of the accessory sexual organs of the male, see Leigh-Sharpe (J. Morph., 36, 1922: 207, fig. 8B [frontal tenaculum], 208–209, figs. 9, 10 [clasper], 209–211, figs. 11, 12 [prepelvic tenaculum]).

124. We have examined capsules from Chile and from Peru, their identities established by close resemblance to others that have been taken from the parent fish (Graham, Trans. Proc. roy. Soc. N. Z., 69 [3], 1939: 362; Whitley, Fish. Aust., 1, 1940: 46, 237) or have been seen protruding from the oviducts ready to be deposited. See Dean (Chimaeroid Fishes, Publ. Carneg. Instn., 32, 1906: 32–34, figs. 15–15F) for reproductions of earlier illustrations of egg capsules; see also Parker and Haswell (Textb. Zool., 2, 1897: 182, fig. 805) for illustration of egg capsule with embryo far advanced in development.

or less definite fringe; they also spread onto the embryo case here or there. The embryo case is spindle-shaped, narrowing abruptly to more tubular extensions, anterior and posterior; the latter is the longer of the two and is continued as a filament which has been broken off on most of the capsules that have been seen. The lateral flanges are broad, with many conspicuous transverse thickenings. There are no median longitudinal keels on the embryo case, which is more strongly convex on the smooth side than on the hairy side. At first the egg capsules are hermetically sealed against the entrance of water.[125] But a slit of considerable length opens later on the concave surface of the posterior extension of the embryo case on either side in the angle with the lateral flange, allowing for respiration. And an opercular slit with thickened edges that do not interlock opens along each side of the anterior extension of the case on the convex (hairy) side. The embryo may lie in its case with either its right- or left-hand side next to the hairy side of the capsule, i.e., against the surface on which the opercular slits open.[126] The case fractures crosswise between the anterior ends of the opercular slits when the young fish escapes.

Range and Depth. Callorhinchus appears to be restricted to cool-temperate and boreal latitudes in the southern hemisphere: southern coast of South America from Uruguay and northern Argentina around to Patagonia, Tierra del Fuego, Chile, and Peru; New Zealand; southern Australian waters, Bass Strait, and Tasmania; also South Africa, from Algoa Bay on the east, about Lat. 34° S, around the Cape of Good Hope to Walfish Bay on the west, about Lat. 23° S. It is taken most often in depths of 5–30 fathoms; in fact, it sometimes enters harbors and even rivers in great numbers,[127] and it is described[128] as abundant in shallow water off the west coast of South Africa, but it has been trawled down to 100 fathoms or deeper.[129]

Species. It is still an open question whether all of the described members of the genus represent varieties of one wide-ranging species, *C. callorynchus* (Linnaeus) 1758, or whether there are several distinct species: *C. milii* Bory de St. Vincent 1823 of Australia; *C. capensis* Duméril 1865 of South Africa; *C. callorynchus* (Linnaeus) 1758 and *C. smythii* Lay and Bennett 1839 of South America, and perhaps even a third South American species, *C. tritoris* Garman 1904.[130]

125. The future openings, anterior and posterior, are foreshadowed only by longitudinal thickenings of the shell on a *Callorhinchus* egg capsule examined by us in a stage so early in development that no trace of the future embryo is to be seen on the enclosed egg.
126. Pictured by Parker and Haswell (Textbk. Zool., *2*, 1897: 182, fig. 805) as having its right-hand side next to the hairy side of the capsule, and it is likewise in one that we have examined, but in another case it is pictured as having its right-hand side next to the smooth side of the capsule (Bridge, Camb. Nat. Hist., *7*, 1904: 471, fig. 270; specimen in Cambridge University Museum).
127. In Tasmania; Whitley, Fish. Aust., *1*, 1940: 238–239.
128. Gilchrist, Fish. Mar. Biol. Surv. S. Afr., Rep. 2, Spec. Rep. 3 (1921), 1922: 51.
129. Off New Zealand; Whitley, Fish. Aust., *1*, 1940: 239.
130. Garman (Mem. Harv. Mus. comp. Zool., *40*, 1911: 97) recognized all of these, while Fowler (Bull. U. S. nat. Mus., 100 [*13*], 1941: 506, 510) retains all but *tritoris*, which he relegates to the synonymy of *smythii*. But Norman (Discovery Rep., *16*, 1937: 35), pointing out that the grinding ridges on the dental plates and the length of the pectoral fin vary too widely for use as specific characters, not only unites *smythii* with *callorynchus* but thinks it probable that both *capensis* and *milii* will prove to be only varieties of it. An examination of specimens from Chile, from Peru, and from Australia inclines us to favor this view.

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